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GEOMETRICAL DRAWING
ARCHITECTURAL DRAWING
FREEHAND AND ORNAMENTAL DRAWING
ADVANCED ARCHITECTURAL DRAWING
ARCHITECTURAL PERSPECTIVE DRAWING
SHADES AND SHADOWS
SKETCHING AND MEASURING
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GEOMETRICAL DRAWING

INSTRUMENTS AND MATERIALS

NOTE.—The student is urged to read very carefully Arts. **23, 24, 35, 36,** and **40.**

1. A **drawing** is a representation of an object or objects on a plane surface by means of lines or lines and shades. If done by the use of the free hand only, it is called **freehand drawing** or **sketching**; if instruments are used, ensuring greater exactness, it is called **instrumental,** or **mechanical, drawing.**

2. All the instruments and materials required for the courses in drawing are mentioned in the following descriptions:

The **drawing-board** should be made of well-seasoned, straight-grained pine, the grain running lengthways. For this Course, a board of the following dimensions is required: length over all, 23 inches; width, 16 inches.

The drawing-board illustrated in Fig. 1 can be fully recommended as possessing the qualities a good and accurate board

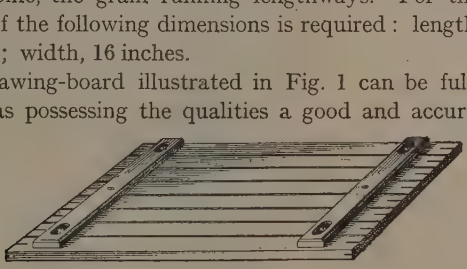

FIG. 1

should have. It is made of several pieces of pine wood glued together to the required width of the board. A pair of hard-wood battens are screwed to the back of the board, the screws passing through the battens in oblong slots with iron bushes, allowing the screws to adjust themselves readily when the board expands and contracts. Grooves are cut through half the thickness of the board over the entire back. These grooves take

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the transverse resistance out of the wood and allow it to be controlled by the battens, at the same time leaving the longitudinal strength nearly unimpaired. In order to provide a perfectly smooth working edge for the head of the **T** square to slide against, a strip of hard wood is let into the short edges of the board, and is sawn through in several places, in order to allow for the contraction and expansion of the board. The battens also raise the board from the table, thus making it easier to change the position of the board. When in use, the board is placed so that one of the short edges is at the left of the draughtsman, as shown in Fig. 2.

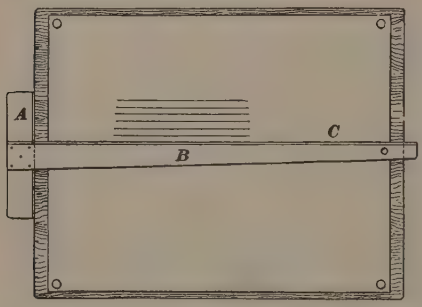


FIG. 2

3. The **T square** is used for drawing horizontal straight lines. The head *A* is placed against the left-hand edge of the board, as shown in Fig. 2. The upper edge *C* of the blade *B*

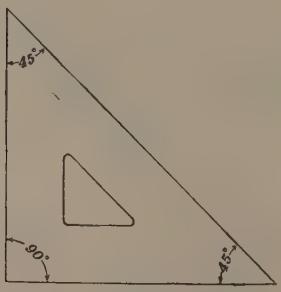


FIG. 3

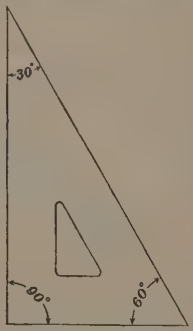


FIG. 4

is brought very near to the point through which it is desired to pass a line, so that the straight edge *C* of the blade may be used as a guide for the pen or pencil. It is evident that all lines drawn in this manner will be parallel.

Vertical lines are drawn by means of **set-squares**, made of celluloid, vulcanite, or wood. The set-squares most generally used are shown in Figs. 3 and 4, each of which has one right angle. The set-square shown in Fig. 3 has two angles of 45° each, and that in Fig. 4 one of 60° and one of 30°. They are called *45° and 60° set-squares*, respectively. To draw a vertical line, place the **T** square in position to draw a horizontal line, and lay the set-squares against it, so as to form a right angle. Hold both **T** square and set-square lightly with the left hand, so as to keep them from slipping, and draw the line with the pen or pencil held in the right hand, and against the edge of the set-square. Fig. 5 shows the set-squares and **T** square in position.

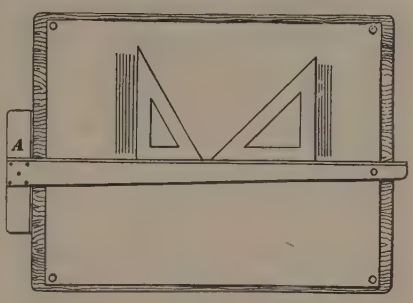


FIG. 5

4. For drawing parallel lines that are neither vertical nor horizontal, the simplest and best way, when the lines are near

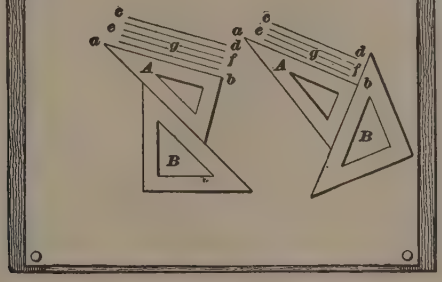


FIG. 6

together, is to place one edge of a set-square, as *a b*, Fig. 6, on the given line *c d*, and lay the other set-square, as *B*, against

one of the two edges, holding it fast with the left hand; then move the set-square A along the edge of B. The edge $a\,b$ will be parallel to the line $c\,d$; and when the edge $a\,b$ reaches the point g, through which it is desired to draw the parallel line, hold both set-squares stationary with the left hand and draw the line $e\,f$ by passing the pencil along the edge $a\,b$. Should the set-square A extend too far beyond the edge of the set-square B after a number of lines have been drawn, hold A stationary with the left hand and shift B along the edge of A with the right hand and then proceed as before.

5. A line may be drawn at right angles to another line which is neither vertical nor horizontal, as illustrated in Fig. 7. Let $c\,d$ be the given line (shown at the left-hand side). Place one of the shorter edges, as $a\,b$, of the set-square B so that it will coincide with the line $c\,d$, then, keeping the set-square in this position, place the set-square A so that its long edge will come against the long edge of B. Now, holding A securely in place with the left hand, slide B along the edge of A with the right hand, when the lines $h\,i$, $m\,n$, etc., may be drawn perpendicular to $c\,d$ along the edge $b\,f$ of the set-square B. The dotted lines show the position of the set-square B when moved along the edge of A.

6. The right-hand portion of Fig. 7 shows another method of accomplishing the same result, and illustrates how the set-squares may be used for drawing a rectangular figure, when the sides of the figure make an angle with the T square such that the latter cannot be used.

Let the side $c\,d$ of the figure be given. Place the *long* side of the set-square B so as to coincide with the line $c\,d$, and bring the set-square A into position against the lower side of B, as shown. Now, holding the set-square A in place with the left hand, revolve B so that its other short edge will rest against the long edge of A, as shown in the dotted position at B'. The parallel lines $c\,e$ and $d\,f$ may now be drawn through the points c and d by sliding the set-square B on the set-square A, as described in connection with Fig. 6. Measure off the required width of the figure from c to e on the line $c\,e$, reverse the set-square B again to its original position, still holding the set-square A in a fixed

position with the left hand, and slide B upon A until the long edge of B passes through e. Draw the line $e\,f$ through the point e,

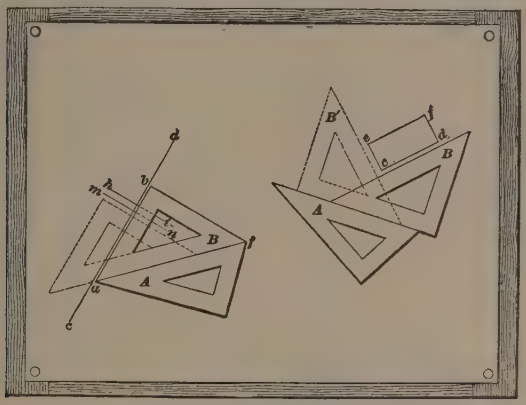


Fig. 7

and $e\,f$ will be parallel to $c\,d$. The beginner should practise with his set-squares before attempting to do drawing.

7. The **compasses**, next to the **T** square and set-squares, are used more than any other instrument. A pencil and pen point are provided, as shown in Fig. 8, either of which may be inserted into a socket in one leg of the instrument, for the drawing of circles in pencil or in ink. The other leg is fitted with a needle point, which acts as the centre about which the circle is drawn. In all good instruments the needle point itself is a separate piece of round steel wire, held in place in a socket provided at the end of the leg. The wire should have a square shoulder at its lower end, below which a fine, needle-like point should project. The *lengthening bar*, also shown in the figure, is used to extend the leg carrying the pen and pencil points when circles of large radii are to be drawn.

8. The joint at the top of the compasses should hold the legs firmly in any position, and at the same time should permit them to be opened or closed with one hand. The joint may be tightened or loosened by means of the screwdriver or wrench that accompanies the compasses.

It will be noticed in Fig. 8 that each leg of the compasses is jointed; this is done so that the compass points may always be kept perpendicular to the paper when drawing circles, as in Fig. 11.

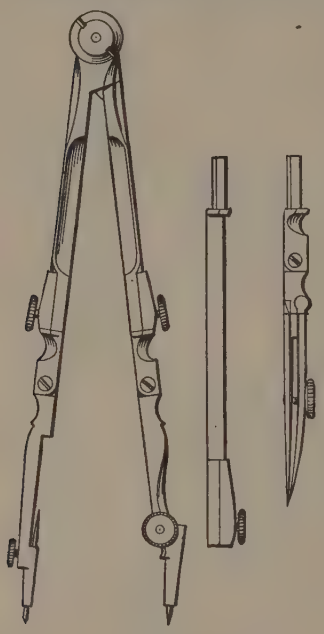


Fig. 8

The compasses which are shown in Fig. 8 have what is called a *tongue joint*, in which the head of one leg has a tongue, generally of steel, which moves between two lugs on the other leg. Another style of joint, as shown in Fig. 9, is the *pivot joint*, in which the head of each leg is shaped like a disc and the two discs are held together in a fork-shaped brace either by means of two pivot screws or by one screw penetrating both discs. The brace that forms a part of this joint is generally provided with a handle, as shown in the illustration.

9. The following suggestions for handling the compasses should be carefully observed by those who are beginning the subject of mechanical drawing. Any draughtsman who handles his instruments awkwardly will create a bad impression, no

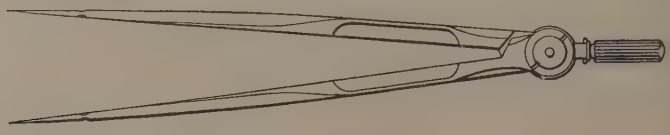


Fig. 9

matter how good a workman he may be. The tendency is to use both hands for operating the compasses. This is to be avoided. The beginner should learn at the start to open and

close them with one hand, holding them as shown in Fig. 10, with the needle-point leg resting between the thumb and the fourth finger, and the other leg between the middle finger and the forefinger. When drawing circles, hold the compasses lightly at the top between the thumb and forefinger, or thumb, forefinger, and middle finger, as in Fig. 11. Another case where both hands should not be used is in locating the needle point at the point on a drawing about which a circle is to be drawn, unless the left hand is used merely to steady the needle point. Hold the compasses as shown in Fig. 10, and incline them until the under side of the hand rests upon the paper. This will steady the hand so that the needle point can be brought to exactly the right place on the drawing. Having placed the needle at the desired point, and with it still resting on the paper, the pen or pencil point may be moved out or in to any desired radius, as indicated in Fig. 10. When the lengthening bar is used, both hands must be employed.

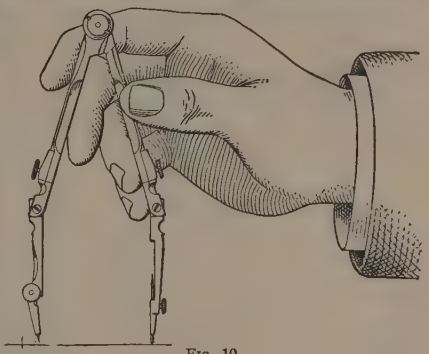


FIG. 10

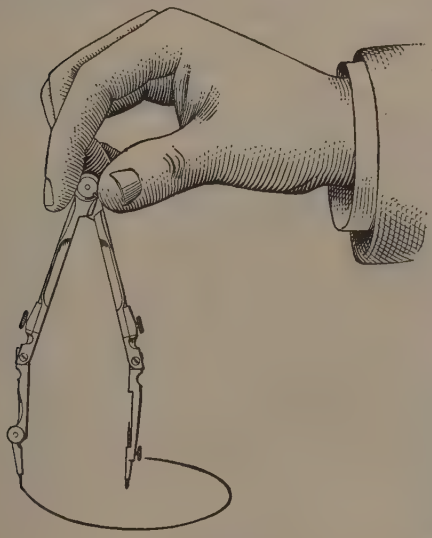


FIG. 11

10. The compasses must be handled in such a manner that the needle point will not dig large holes in the paper. Keep the needle point adjusted so that it will be perpendicular to the paper, when drawing circles, and *do not bear upon it.* A slight pressure will be necessary on the pen or pencil point, *but not on the needle point.*

11. The **dividers,** shown in Figs. 9 and 12, are used for laying off distances on a drawing, or for dividing straight lines or circles into parts. The points of the dividers should be *very* sharp, so that the holes in the paper will be no larger than is absolutely necessary to be seen. Compasses are sometimes furnished with two steel divider points, besides the pen and pencil points, so that the instrument may be used either as compasses or dividers. This is the kind illustrated in Fig. 12. When using the dividers to space a line or a circle into a number of equal

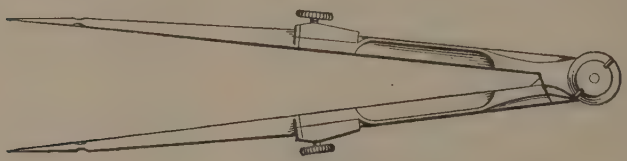


FIG. 12

parts, hold them at the top between the thumb and the forefinger, as when using the compasses, and step off the spaces, turning the instrument alternately to the right and left. If the line or the circle does not space exactly, vary the distance between the divider points and try again ; so continue until the line or the circle is spaced equally. When spacing in this manner, great care must be exercised not to press the divider points into the paper ; for, if the points enter the paper, the spacing can never be accurately done. The truth of this statement may be proved by actual trial.

12. The **spring bows,** pencil and pen points, hereafter called, for brevity, **bow-pencil** and **bow-pen,** shown in Fig. 13, are convenient for describing small circles. The two points must be the same length ; otherwise very small circles cannot be drawn. To

adjust either instrument, hold it vertically by resting the needle point on the paper and bearing lightly on the top with the forefinger of one hand, and turn the adjusting nut with the thumb and middle finger.

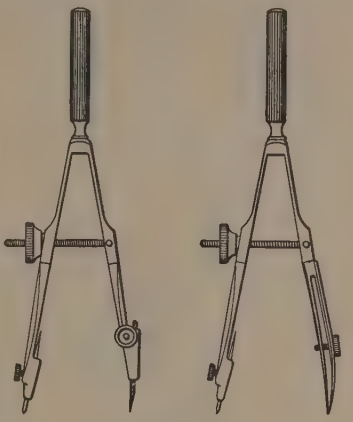


Fig. 13

13. Drawing Paper and Pencils.—The drawing paper recommended for this series of lessons is a white, cold-pressed paper, $22'' \times 15''$ in size. It takes ink well and withstands considerable erasing. The paper is secured to the drawing-board by means of **drawing-pins.** Four are usually sufficient—one at each corner of the sheet (see Fig. 7). Place a piece of paper on the drawing-board, and press a drawing-pin through one of the corners about $\frac{1}{4}$ or $\frac{3}{8}$ of an inch from each edge. Place the **T** square in position for drawing a horizontal line, as before explained, and straighten the paper so that its upper edge will be parallel to the edge of the **T**-square blade. Pull the corner diagonally opposite that in which the drawing-pin was placed, so as to stretch the paper slightly, and push in another drawing-pin. Do the same with the two remaining corners. For drawing in pencil, a 4 H pencil of any reputable make should be used. The pencil should be sharpened as shown at *A*, Fig. 14. Cut the wood away so as to leave about $\frac{1}{4}$ or $\frac{3}{8}$ of an inch of the lead projecting; then sharpen it flat by rubbing it against a fine file or a piece of fine emery cloth or sandpaper that has been

A *B*

Fig. 14

fastened to a flat stick. Grind it to a sharp edge like a knife blade, and round the corners very slightly, as shown in the figure. If sharpened to a round point, as shown at *B*, the point will wear away quickly and make broad lines ; a pencil so sharpened is not used to draw a straight line exactly through a point. The lead for the compasses should be sharpened in the same manner as the pencil, but should have its width narrower. *Be sure that the compass lead is so secured that, when circles are struck in either direction, only one line will be drawn with the same radius and centre.*

14. Inking.—For drawing ink lines other than arcs of circles, the **drawing pen** (or *ruling pen*, as it is sometimes called) is used. It should be held nearly perpendicular to the board, slanting a trifle in the direction in which the line is being drawn. The hand will have the position shown in Figs. 15 and 16, bearing lightly against the T square or set-square, along the edge of which the line is drawn. After a little practice, this position will become natural, and no difficulty will be experienced.

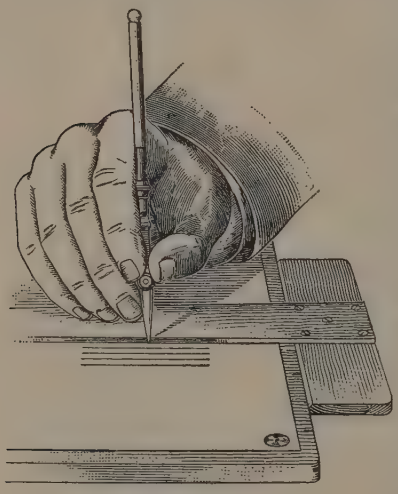


Fig. 15

15. The beginner will find that it is not always easy to make smooth lines. If the pen is held so that only one blade bears on the paper when drawing, the line will almost invariably be ragged on the edge where the blade does not bear. When held at right angles to the paper, as in Fig. 16, however, both blades will rest on the paper, and if the pen is in good condition, smooth lines will result. The pen must not be pressed against the edge of the T square or set-square, as the

blades will then close together, making the line uneven. The edge should serve simply as a guide.

In drawing circles with the compass pen, the same care should be taken to keep the blades perpendicular to the paper by means of the adjustment at the joint. In both the ruling pen and the

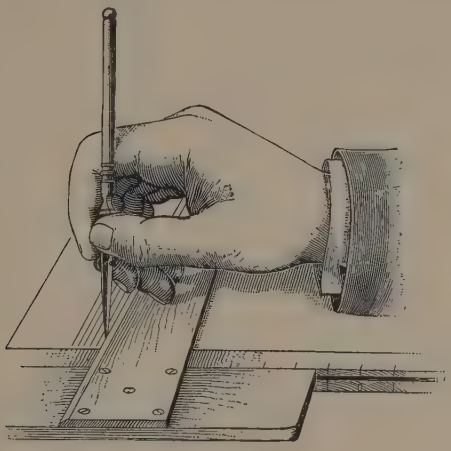


Fig. 16

compass pen, the width of the lines can be altered by means of the screw which holds the blades together. The handles of some ruling pens can be unscrewed, and are provided with needle points intended for use when copying maps by pricking through the original and the underlying paper, thus locating a series of points through which the outline may be drawn.

16. Drawing Ink.—The ink recommended for the work in this Course is waterproof liquid Indian ink, which can be procured in small bottles. A quill, attached to the cork of the bottle, readily enables the pen to be filled. Dip the quill into the ink and then pass the end of it between the blades of the drawing pen. Do not put too much ink in the pen, not more than enough to fill it for a quarter of an inch along the blades, otherwise the ink is liable to drop. Many draughtsmen prefer to use stick Indian ink, and for some purposes this is better than liquid ink.

The advantage in using liquid ink is that the lines of the drawing will all be of the same colour, and the work of grinding the stick ink is avoided. A good stick ink is economical, however, as a small stick of the best quality, costing about four shillings, will last as long, perhaps, as a pound's worth of liquid ink. If the stick ink is to be used, put sufficient water in a small shallow dish to make enough ink for the drawing, place one end of the stick in the water, and grind by giving the stick a circular motion, but do not bear hard on it. Test the ink occasionally, to see if it is black, by drawing a fine line with the pen. Hold the paper in a strong light, and if the ink shows brown or grey, grind a little longer, then test again. Continue grinding and testing until a fine line shows *black*, which will usually take from fifteen minutes to half an hour, depending upon the quantity of water used. The drawing pen is filled by dipping an ordinary writing pen into the ink and passing it between the blades as in using the quill. The ink should always be kept well covered to keep out dust and prevent evaporation.

17. Indian ink will dry quickly on a drawing, which is desirable, but it also causes trouble by drying between the blades and refusing to flow, especially when drawing fine lines. *The only remedy is to wipe out the pen frequently* with a cloth. Do not lay the pen down for any great length of time when it contains ink ; wipe it out first. The ink may sometimes be started by moistening the end of the finger and touching it to the point, or by drawing a slip of paper between the ends of the blades. *Always keep the bottle corked.*

18. To Sharpen the Drawing Pen.—When the drawing, or the compass, pen becomes badly worn, it must be sharpened. For this purpose a fine oilstone should be used. If an oilstone is to be purchased, a small, flat, close-grained stone should be obtained, one having a triangular section being preferable, as the narrow edge can be used on the inside of the blades in case the latter are not made to swing apart so as to permit the use of a thicker edge.

The first step in sharpening is to screw the blades together, and, holding the pen perpendicular to the oilstone, then draw it

to and fro over the stone, changing the slope of the pen from downwards and to the right to downwards and to the left for each movement of the pen to the right and to the left. The object of this is to bring the blades to exactly the same length and shape, and to round them nicely at the point.

This process, of course, makes the edges even duller than before. To sharpen them, separate the points by means of the screw, and rub one of the blades to and from the operator in a straight line, giving the pen a slight twisting motion at the same time, and holding it at an angle of about 15° with the face of the stone. Repeat the process for the other blade. To be in good condition, the edges should be fairly sharp and smooth, but not sharp enough to cut the paper. *All the sharpening must be done on the outside of the blades.* The inside of the blades should be rubbed on the stone only enough to remove any burr that may have been formed. Anything more than this will be likely to injure the pen. The whole operation must be done very carefully, bearing on lightly, as it is easy to spoil a pen in the process. Examine the points frequently, and keep at work until the pen will draw both *fine* lines and *smooth*, heavy lines. Many draughtsmen prefer to send their pens that require sharpening to a drawing-instrument shop, where they will be sharpened at a trifling cost.

Fig. 17

19. French Curves.—Curves other than arcs of circles are drawn with the pencil or ruling pen by means of curved or irregular-shaped rulers, called **French curves,** one of which is shown in Fig. 17. A series of points is first determined through which the curved line is to pass. The line is then drawn through these points by using such parts of the French curve as will pass through several of the points at once, the curve being shifted from time to time as required.

It is usually difficult to draw a smooth, continuous curve. The tendency is to make it curve out too much between the

points, thus giving it a wavy appearance, or else to cause it to change its direction abruptly where the different lines join, making angles at these points. These defects may largely be avoided by always fitting the curve to at least three points, and, when moving it to a new position, by setting it so that it will coincide with part of the line already drawn. It will be found to be a great help if the line is first sketched in freehand in pencil. It can then be pencilled over neatly, or inked, without much difficulty, with the aid of the French curve, since the original pencil line will show the general direction in which the curve should be drawn. Whenever the given points are far apart, or fall in such positions that the French curve cannot always be made to pass through three of them, the line must invariably be sketched in first with a pencil sharpened as at *B*, Fig. 14.

20. As an example, let it be required to draw a curved line through the points *a*, *b*, *c*, *d*, etc., Fig. 18. As just stated, a part of the French curve must be used which will pass through at least three points. With the curve set in the first position *A*, its edge is found to coincide with four points, *a*, *b*, *c*, and *d*. The line may then be drawn from *a* round to *d*, or, better, to a point between *c* and *d*, since, by not continuing it quite to *d*, there is less liability of there being an angle where it joins the next section. For the next section of the line, the curve should be adjusted so as to coincide with a part of the section already drawn; that is, instead of adjusting it to points *d*, *e*, *f*, etc., it should be so placed as to pass through the point *c*, the part from *c* to *d* being coincident with the corresponding part of the first line drawn. The French curve is shown dotted in this position at *B*. Its edge passes through four points, *c*, *d*, *e*, and *f*, and the line should be made to stop midway between the last two, as before.

Now, it will be noticed that the points *f* and *g* are so situated that the remainder of the line must curve up, instead of down, as hitherto, the change in curvature occurring at a point between *e* and *f*. In this case, therefore, it is not necessary for the curve to extend back to *e*, through which point the line has already

been drawn, but it may be placed in position *C* with its edge just tangent to the line at the point where the curvature changes.

It is to be noticed that in inking with the French curve, the blades of the pen must be kept tangent to its edge (i.e., the

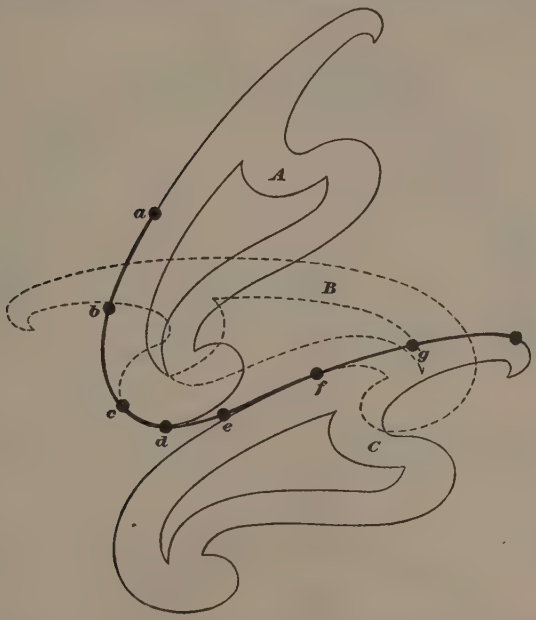


Fig. 18

inside flat surface of the blades must have the same direction as the curve at the point where the pen touches the paper), which requires that the direction of the pen should be continually changed.

21. The scale is used for obtaining measurements for drawings. The most convenient forms are the usual flat and triangular boxwood scales, having bevelled edges, each of which is graduated for a distance of 12 inches. The bevelled edges serve to bring the lines of division close to the paper when the scale is lying flat, so that the drawing may be accurately

measured, or distances laid off correctly. The use of the graduations on scales will be explained when it is necessary to use the scale.

22. A **protractor** is shown in Fig. 19. The outer edge is a semicircle, with its centre at *O*, and is divided into 360 parts.

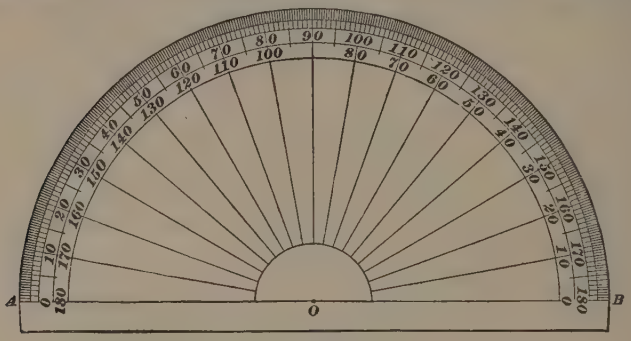


FIG. 19

Each division is one-half of one degree, and, for convenience, the degrees are numbered from 0° to 180° from both *A* and *B*. The protractor is used for laying off or measuring angles. It is made of celluloid or of metal. When made of metal, the central

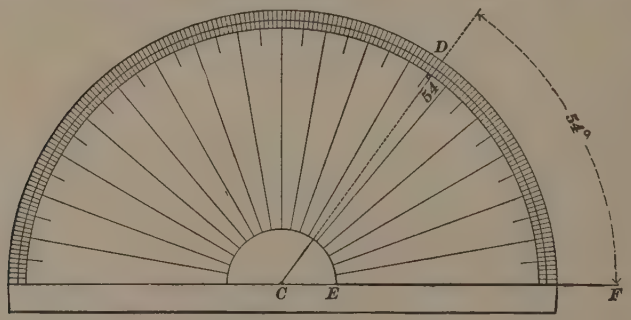


FIG. 20

part is cut away to make the drawing under it visible. When using the protractor, it must be placed so that the line *O B*, Fig. 19, will coincide with the line forming one side of the angle

to be laid off or measured, and the centre *O* must be at the vertex of the angle.

For example, let it be required to draw a line through the point *C*, making an angle of 54° with the line *E F*, Fig. 20. Place the protractor upon the line *E F*, as just described, with the centre *O* upon the point *C*. With a sharp-pointed pencil, make a mark on the paper at the 54° division, as indicated at *D*. A line drawn through *C* and *D* will then make an angle of 54° with *E F*. Greater exactness will be secured if the line *E F* is extended to the left, so that both zero marks (*A* and *B*, Fig. 19) can be placed on the line. This should always be done when possible.

LETTERING

23. In mechanical drawing, all headings, explanatory matter, and dimensions should be neatly printed on the drawing. Ordinary script writing is not permissible.

It is usually difficult for the beginner to letter well, and unless he is skilful at it, he should devote some time to practising lettering before commencing the drawing. In correcting the plates, the lettering will be considered as well as the drawing. Many think that it is necessary to exercise special care only when drawing the views on a plate, and that it is not necessary to take particular pains in lettering. This, however, is not the case, for, no matter how well the views may be drawn, if the lettering is poorly done, the finished drawing will not have a neat appearance. In fact, generally speaking, more time is required to make well-executed letters than to make well-executed drawings of objects. The beginner is earnestly requested to practise lettering, and not to think that this part of the work is of no importance. He should not be too hasty in doing the lettering. It takes an experienced draughtsman considerable time to do good lettering, and no draughtsman can perform this work as quickly as he can ordinary writing; therefore, no beginner should attempt to do what experienced draughtsmen cannot do. In order to letter well, the work must be done slowly; very frequently more time is spent

in lettering a drawing than in inking in the objects represented. Instructions will be given in two styles of freehand lettering, both extensively used in drawing offices.

24. With the exception of the large headings or titles of the plates, the style and size of all lettering used on the original drawing plates of this subject are shown in Fig. 21. This style, although more difficult in execution than that shown in Fig. 25, is selected on account of its greater neatness and legibility. The two styles are very similar in the formation of the letters,

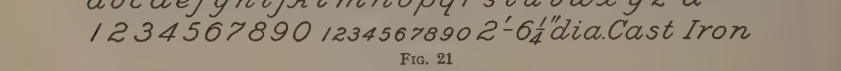


FIG. 21

but it is advisable to select and use only one of the two on the drawings in this Course. After having mastered one of the styles, little difficulty will be experienced in practising the other.

When lettering, a Gillott's No. 303 pen should be used. The height of the capital letters should be $\frac{3}{32}''$, and that of the small letters two-thirds of this, or $\frac{1}{16}''$. This applies to both styles of freehand lettering. *Do not make them larger than this.*

25. Before beginning to letter, horizontal guide lines should be drawn with the T square, to serve as a guide for the tops and bottoms of the letters (see Fig. 22). The outside lines should be $\frac{3}{32}''$ apart for the capitals, and the two lower lines $\frac{1}{16}''$ apart for the small letters. The letters should be made to extend fully up to the top, and down to the bottom, guide lines. They must not fall short of the guide lines, nor extend beyond them. Failure to observe this point will cause the lettering to look ragged, as in the second word in Fig. 22.

FIG. 22

26. It is very important that all the letters have the same inclination. For example, by referring to Fig. 23 (*a*), it will be seen that the backs of letters like *B*, *E*, *l*, *g*, *d*, *i*, *t*, etc., are parallel and slant the same way. This is

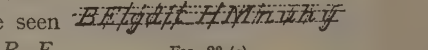


FIG. 23 (*a*)

also true of both sides of letters like *H*, *M*, *n*, *u*, *h*, *y*, etc. To aid in keeping the slant uniform, draw parallel slanting lines across the guide lines with the 60° set-square, as in Fig. 23 (*b*), and, in lettering, make the backs or sides of the letters parallel with those lines.

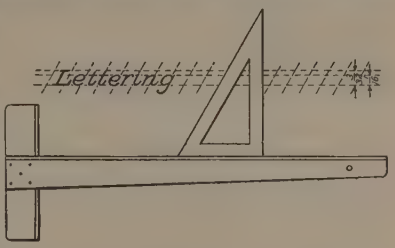


Fig. 23 (*b*)

27. A few points regarding the construction of the letters are illustrated in Fig. 24, in which the letters are shown on an enlarged scale. The capital letters *A*, *V*, *Y*, *M*, and *W* must be printed so that their general inclination will be the same as for the other letters. To print the *A*, draw the centre line *a d*, having the common slant; from *a* draw the sides *a c* and *a b*, so that points *c* and *b* will each be $\frac{3}{64}''$ distant from point *d*. The side *a b* will be nearly perpendicular to the guide lines. The *V* is like an inverted *A*, and is drawn in the same way, the line *b d* being nearly perpendicular.

To make the *Y*, draw the centre line *a d*, having the common slant, which gives the slant for the base of the letter. The upper part of the *Y* begins a little below its centre, and is similar to the *V*, though somewhat narrower, as the letter should be only $\frac{5}{64}''$ wide at the top. Points *b* and *c* should be at equal distances from point *a*.

The two sides *b c* and *e f* of the *M* are parallel, and have the common slant. The *M* is made as broad as it is high, or $\frac{3}{32}''$.

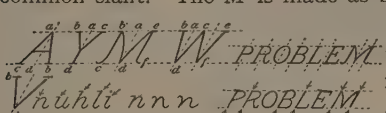


Fig. 24

Having drawn the two sides, mark the point *d*, midway between the points *c* and *f*, and connect it with points *b* and *e*. The lines *b d* and *e d* should be slightly curved, as shown.

In the *W* the two outside lines are not parallel, as in the *M*, but are farther apart at the top than at the bottom. Draw

the line *a d*, having the common slant. Mark points *b* and *c*, which are exactly $\frac{1}{32}''$ from the point *a*. From *b* and *c*, draw lines *b d* and *c d*. The other half of the *W* is like the first part, *c f* being parallel to *b d* and *e f* parallel to *c d*. It will be seen that the *W* is composed of two narrow *V*'s, each $\frac{1}{16}''$ wide, the width of the whole letter being $\frac{1}{8}''$.

28. Capital letters like *P*, *R*, *B*, *L*, *E*, etc., should be printed so that their top and bottom lines will be *exactly horizontal*. This is illustrated in the two examples of the word *problem* in Fig. 24. In the first example, it will be noticed that the tops of the *P* and *R*, the bottom of the *L*, and the tops and bottoms of the *B* and *E*, all run in the same direction as the guide lines, and coincide with them. In the second example these lines are not horizontal, which makes the word look very uneven. It is also to be noticed that these lines extend beyond the upright lines in the first word, and that cross-lines are used on the bottom of the *P* and *R*, on the top of the *L*, and on the *M*. In the second word, these lines are omitted at the points indicated by the arrows. These features are found on most of the other capitals.

The small letters *n*, *u*, *h*, *l*, *i*, etc., should have sharp corners at the points indicated by the arrows in Fig. 24. They look much better that way, and are less difficult to make than when they have round corners. Following these letters are five groups of letters containing *n*, *u*, *l*, *g*, and *r*. The first letter of each group is printed correctly, while the letters following show ways in which they should *not* be printed. In the case of the *g*, point *2* should fall in a slanting direction under point *1*, the slant being the same as *a d* of the preceding letters. The difference between *d* and *b* and the construction of the *s* are also shown in the same figure. The *b* should be rounded at the point indicated. As a guide in making the *s*, draw the two lines *a b* and *c d* having the common slant. The *s* should now be drawn so that it will touch these lines at points *1*, *3*, and *4*, but *not* at point *2*. It will be an additional help if the line *e x* is also drawn as a guide for the middle portion of the *s*; but care should be taken not to have it slant more than shown in the copy.

The letters *a*, *o*, *b*, *g*, etc., should be full and round; do not cramp them. It will be necessary to follow the copy closely until familiar with it. Notice that the figures are not made as in writing, particularly the *6*, *4*, *8*, and *9* (see Fig. 21). Try to space the letters evenly. Letter in pencil first, and, if not right, erase and try again.

29. Another style of freehand lettering is shown in Fig. 25. This style is used extensively for the lettering of working drawings. It is more easily and rapidly made than the style previously described, and although not so neat in appearance will be found very useful and acceptable for general office work. A comparison of the two systems will disclose a great similarity in the details of formation of the letters.

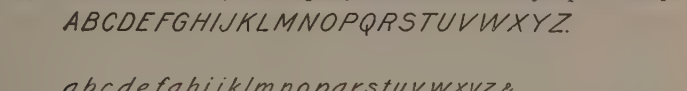


Fig. 25

30. The horizontal and slanting guide lines are drawn in exactly the same manner as for the style previously described, and if not followed, the results will be similar. Observe the uneven appearance of the second word in Fig. 26.

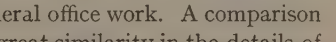


Fig. 26

31. By studying the formation of the letters carefully, it will be found that many of them are formed on the same principle, as shown in Fig. 27.

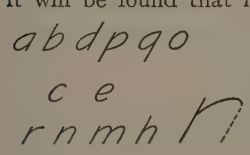


Fig. 27

The ovals of the letters *a*, *b*, *d*, *p*, *q*, and *o* are formed exactly alike and have a slant of 45° with the horizontal. These ovals should be made a little wider at the top than at the bottom. Care should be taken that the straight downward strokes are made parallel to the slanting guide lines. The letters *c* and *e* are commenced in the same way, but

the upper loop in *e* should be formed in such a manner that its axis will be at an angle of 45° with the horizontal. The *r* is made by having the down stroke parallel to the slanting guide line and the up stroke slightly curved in the same way as in the letter *n* (see Fig. 27). The strokes in the letters *j* and *f* are the same, with the position of the hook part reversed.

32. The capital letters shown in Fig. 28 are formed very nearly in the same manner as those shown in Art. **27**, but differ slightly by omitting the short spurs that give to the letters a more finished appearance.

In the capital *M*, however, there is a decided variation. The *M* is made with four strokes, putting in the parallel sides first. The two other strokes should join midway between these sides and

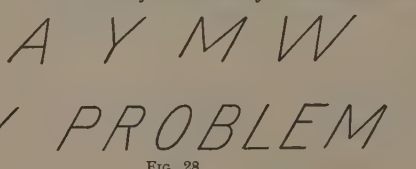


FIG. 28

at a distance from the top of about $\frac{4}{5}$ of the height of the letter. These strokes, as will be seen, are straight and not curved.

33. The *numerals* should be $\frac{3}{32}''$ high and of the style shown in Fig. 25; fractions should be $\frac{1}{8}''$ high over all. In Fig. 29

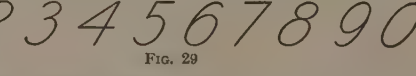


FIG. 29

the numerals are illustrated to a larger scale, and a comparison with the style shown in Fig. 21 will disclose several variations.

The loops of the *2*, *3*, *5*, *6*, and *9* should be formed so that their axes will be at an angle of 45° with the horizontal. It will be noted that the *7* differs widely from the style shown in Fig. 21, the down stroke not curving, but having a straight slant of 45°. The axis of the *0* and the loops of the *8* should slant at an angle of 60°.

Diligent practice for a short time and careful observation of the forms of letters and numerals, as shown in Figs. 21 to 29, will soon ensure skill and speed in this branch of drawing.

34. The alphabet shown in Fig. 30, called the **block letter,** is to be used for the large headings or titles of plates, as shown on the copy plates. This alphabet is *not* to be used on the first five geometrical drawing plates. The letters and figures are to be made $\frac{5}{16}''$ high and $\frac{1}{4}''$ wide, except *M*, which is $\frac{5}{16}''$ wide, and *W*, which is $\frac{3}{8}''$ wide. The thickness of all the lines forming the letters is $\frac{1}{16}''$, measured horizontally. The distance between any two letters of a word is $\frac{1}{16}''$, except where *A* follows *P* or *F*;

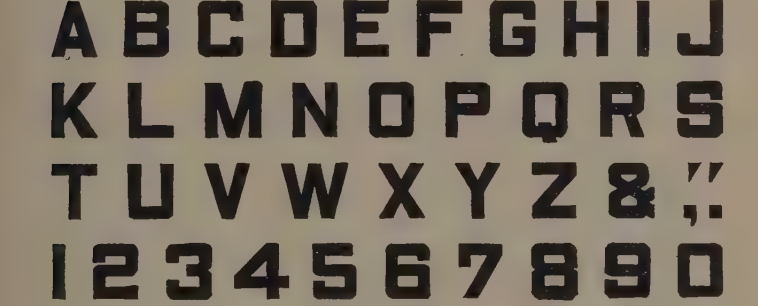


FIG. 30

where *V*, *W*, or *Y* follows *L*; where *J* follows *F*, *P*, *T*, *V*, *W*, or *Y*; where *T* and *A* are adjacent, or *A* and *V*, *W*, or *Y* are adjacent; in this case the bottom extremity of *A* and the top extremity of *P*, *T*, *V*, *W*, are in the same vertical line.

Since these letters are composed of straight lines, they can be made with the **T** square and set-square. In lettering the titles of the drawing plates, six horizontal lines $\frac{1}{16}''$ apart should be drawn in lead pencil, to represent the thickness of the letters at the top, centre, and bottom; then, by use of the set-square, the width of the letters, and the spaces between them, should be drawn in lead pencil. Having the letters all laid out, they can very easily be inked in. Use the ruling pen for inking in the straight outlines of the letters and the lettering pen for rounding the corners and filling in between the outlines. It is well to ink in all the vertical lines first, then the horizontal lines, and, finally, oblique lines.

DRAWING PLATES

35. The empty postal tube (cardboard roll) accompanying this Paper should be used in sending your drawing of Plate I to us. Do not send the plates of this Paper together, but **send one plate at a time.** As soon as you finish Plate I, send it to us, and begin on Plate II. In the meantime we will correct and return your Plate I. On receiving it, you should note carefully all corrections and suggestions that may be sent with it. You will make better progress if you do not send another plate until the previous one has been returned. You will thus have an opportunity to note our corrections and suggestions, and thereby be enabled to avoid further errors of a similar nature.

It is essential that you comply strictly with these directions. By so doing, you will make more rapid progress. Do not be discouraged if there are a large number of corrections on your earlier plates. They are made in order to point out the ways in which your drawing or lettering may be improved, so that your later plates may be as nearly perfect as possible. Our sole aim is to help you to succeed, and we should not be doing our duty if we failed to point out the defects. No one can attain proficiency unless his work is criticized, and numerous corrections do not indicate that we have failed to see any merits in your drawing.

A gummed label, properly filled in, should be attached to every plate you send to us. Neglect of this simple precaution may result in delaying the return of your work.

PRELIMINARY INSTRUCTIONS

36. The size of each plate over all will be $18'' \times 14''$ having a border line $\frac{1}{2}''$ from each edge all round, thus leaving a space $17'' \times 13''$ on which the drawing is to be made. The sheet itself must be larger than this when first placed on the board, so that the drawing-pin holes may be cut out; the margin is

also very convenient for testing the pen, in order to see whether the ink is flowing well and whether the lines are of the proper thickness.

The first five plates of this Course are to be drawn by the methods outlined in the text of this Paper. No specimen copies of these five plates will be furnished. However, for the sixth and all succeeding plates, specimen copies will be sent, and these, together with the text, will indicate the methods to be used in drawing the plates.

The first five plates consist of geometrical problems which constantly arise in practice when making drawings. The methods of solving these problems should be carefully memorized, so that they can be instantly applied when the occasion requires without being obliged to refer to the text for help. Particular attention should be paid to the lettering. Whenever any dimensions are specified, they should be laid off accurately. All drawings should be made as neat as possible, and the pencilling entirely finished before inking in any part of it. Great care should be taken in distributing the different views, parts, details, etc., on the drawing, so that when the drawing is completed one view will not be so near to another as to mar the appearance of the drawing. The hands should be perfectly clean, and should not touch the paper except when necessary. No lines should be erased except when *absolutely* necessary ; for, wherever a line has once been erased, and the surface of the paper thereby removed, the paper becomes soiled very easily.

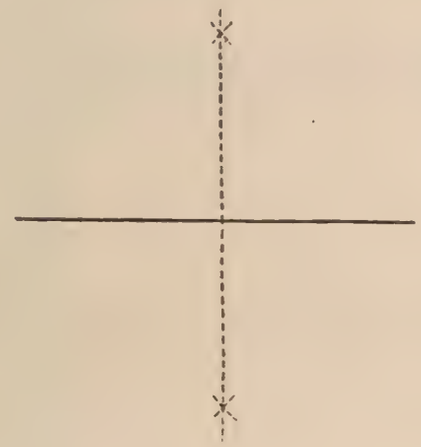
For this reason, all construction lines that are to be removed, or that are likely to be changed, should be drawn lightly so that the finish of the paper may not be destroyed when erasing them. When it is found necessary to erase an ink blot, or a line that has been inked in, only an *ink eraser* or *sand rubber* should be used. After the erasure has been made, the roughened part of the surface of the paper can be smoothed by rubbing with some hard, smooth substance, as a piece of ivory or the handle of a knife. In this way the loosened fibres of the paper are pressed down and a surface is formed, over which a new inked line may be drawn successfully.

PLATE I

37. Fasten a sheet of drawing paper to the board, as previously described, and draw the outlines of the size of the plate $18'' \times 14''$. Draw the border line all round $\frac{1}{2}''$ from the edge of the outline, leaving a space $17'' \times 13''$ inside for the drawing. When the word *drawing* is used hereafter, it refers only to the space inside the border lines and the objects drawn upon it. Remove the folded sheet inserted in this Section, and spread it open, so as to keep it constantly before the eye. On it is drawn Plate I to a reduced scale. Divide the drawing into two equal parts by means of a faint horizontal line. This line is shown dotted in Plate I. Divide each of these halves into three equal parts, as shown by the dotted lines; this divides the drawing into six rectangular spaces. *These division lines are not to be inked in, but must be erased when the plate is completed.* On the first five plates, space for the lettering must be taken into account. For each of the six equal spaces, the lettering will take up one or two lines. The height of all capital letters on these plates will be $\frac{3}{32}''$, and of the small letters $\frac{2}{3}$ of this, or $\frac{1}{16}''$. The distance between any two lines of lettering will also be $\frac{3}{32}''$. The distance between the tops of the letters on the first line of lettering and the top line of the equal divisions of the drawing is to be $\frac{1}{2}''$; and the space between the bottoms of the letters and the topmost point of the figure represented on the drawing within one of these six divisions must also be not less than $\frac{1}{2}''$. This makes a very neat arrangement, if the figure is so placed that the outermost points of the bounding lines are equally distant from the sides of one of the equal rectangular spaces. Consequently, if there is one line of lettering, no point of the figure should come nearer than $\frac{1}{2}'' + \frac{3}{32}'' + \frac{1}{2}'' = 1\frac{3}{32}''$ to the top line of the space within which it is represented, or, if there are two lines of lettering, nearer than $\frac{1}{2}'' + \frac{3}{32}'' + \frac{3}{32}'' + \frac{3}{32}'' + \frac{1}{2}'' = 1\frac{9}{32}''$. The letter heading for each figure on the first five plates will be printed in heavy-faced type at the beginning of the directions explaining each problem. It must be judged by the length of the heading whether it will take up one line or two, and due allowance must be made for

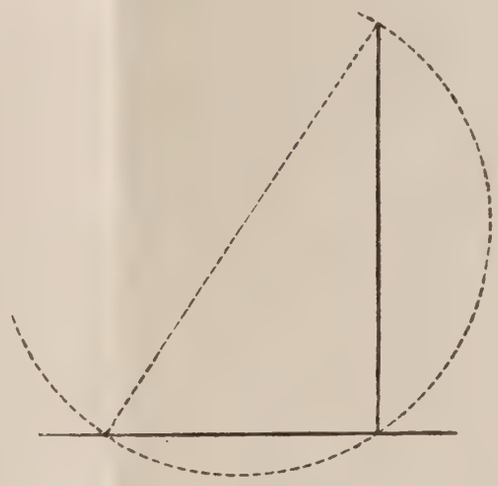
PLATE I.

PROBLEM 1: To bisect a straight line.



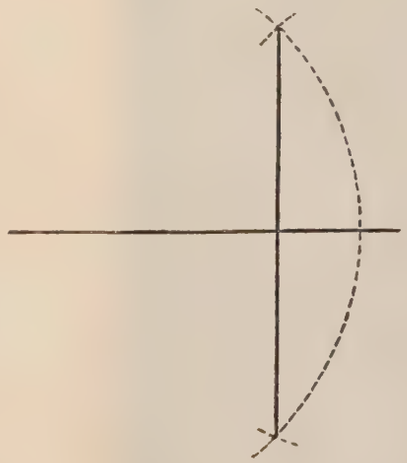
PROBLEM 2: To draw a perpendicular to a straight line from a given point in that line.
CASE I.

CASE II.

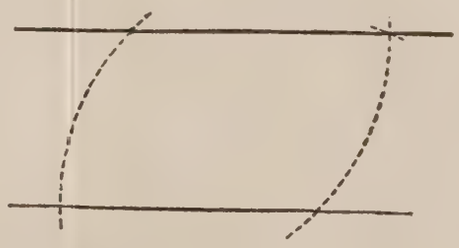


PROBLEM 3: To draw a perpendicular to a straight line from a point without it.
CASE I.

CASE II.



PROBLEM 4: Through a given point to draw a straight line parallel to a given straight line.



DATE

NAME, CLASS LETTERS AND NUMBER.

the space it takes up. This is a necessary precaution, because the lettering should never be done until the rest of the drawing is entirely finished and inked in.

Problem 1.—To bisect a straight line.
See Fig. 31 ; also 1 of Plate I.

CONSTRUCTION.—Draw a straight line $A\,B$, $3\frac{1}{2}''$ long. With one extremity A as a centre, and a radius greater than one-half of the length of the line, describe an arc of a circle on each side of the given line; with the other extremity B as a centre, and the same radius, describe arcs intersecting the first two in the points C and D. Join C and D by the line $C\,D$, and the point P, where it intersects $A\,B$, will be the required point; that is, $A\,P = P\,B$, and P is the middle point of $A\,B$. Since $C\,D$ is perpendicular to $A\,B$, this construction also gives a *perpendicular to a straight line at its middle point.*

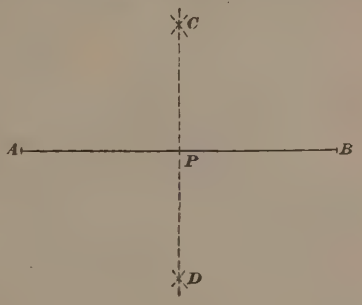


FIG. 31

Problem 2.—To draw a perpendicular to a straight line from a given point in that line.

NOTE.—As there are two cases of this problem, requiring two figures on the plate, the line of letters will be run clear across both figures, as shown in Plate I.

Case I.—*When the point is at or near the centre of the line.* See Fig. 32 ; also 2, Case I, of Plate I.

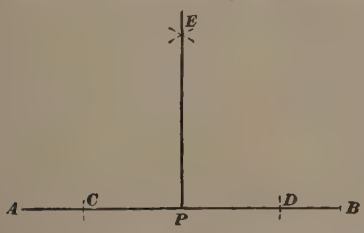


FIG. 32

CONSTRUCTION.—Draw $A\,B$ $3\frac{1}{2}''$ long. Let P be the given point. With P as a centre, and any radius, as $P\,D$, describe two short arcs cutting $A\,B$ in the points C and D. With C and D as centres, and any convenient radius greater than $P\,D$,

describe two arcs intersecting in *E*. Draw *P E*, and it will be perpendicular to *A B* at the point *P*.

Case II.—*When the point is near the end of the line.* See Fig. 33 ; also 2, Case II, of Plate I.

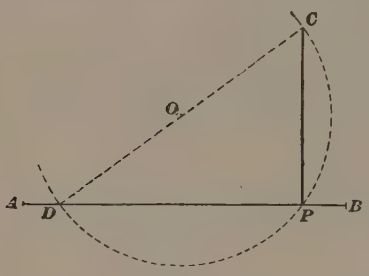


Fig. 33

Construction.—Draw *A B* $3\frac{1}{2}''$ long. Take the given point *P* about $\frac{3}{8}''$ from the end of the line. With any point *O* as a centre, and a radius *O P*, describe an arc cutting *A B* in *P* and *D*. Draw *D O*, and prolong it until it intersects the arc in the point *C*. A line drawn through *C* and *P* will be perpendicular to *A B* at the point *P*.

Problem 3.—To draw a perpendicular to a straight line from a point without it.

As in Problem 2, there are two cases.

Case I.—*When the point lies nearly over the centre of the line.* See Fig. 34 ; also 3, Case I, of Plate I.

Construction.—Draw *A B* $3\frac{1}{2}''$ long. Let *P* be the given point. With *P* as a centre, and any radius *P D* greater than the distance from *P* to *A B*, describe an arc cutting *A B* in *C* and *D*. With *C* and *D* as centres, and any convenient radius, describe short arcs intersecting in *E*. A line drawn through *P* and *E* will be perpendicular to *A B* at *F*.

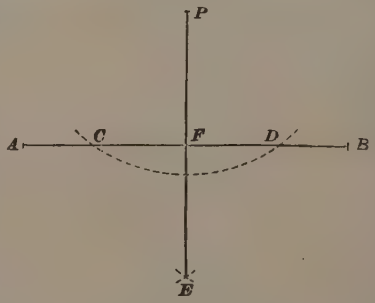


Fig. 34

Case II.—*When the point is nearly over one end of the line.* See Fig. 35 ; also 3, Case II, of Plate I.

Construction.—Draw $A\ B$ $3\frac{1}{2}''$ long, and let P be the given point. With any point C on $A\ B$ as a centre, and with $C\ P$ as a radius, describe an arc $P\ E\ D$ cutting $A\ B$ in E. With E as a centre, and the distance $E\ P$ as a radius, describe an arc cutting the arc $P\ E\ D$ in D. The line joining the points P and D will be perpendicular to $A\ B$.

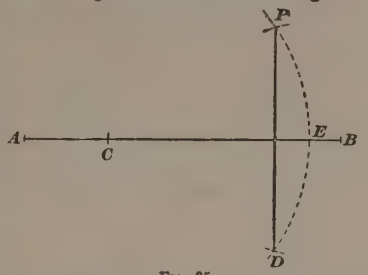


Fig. 35

Problem 4.—Through a given point, to draw a straight line parallel to a given straight line.

See Fig. 36; also 4 of Plate I.

Construction.—Let P be the given point, and $A\ B$ the given straight line $3\frac{1}{2}''$ long. With P as a centre, and any convenient radius, describe an arc $C\ D$ intersecting $A\ B$ in D. With D as a centre, and the same radius, describe the arc $P\ E$. With D as a centre, and a radius equal to the chord of the arc $P\ E$, describe an arc intersecting $C\ D$ in C. A straight line drawn through P and C will be parallel to $A\ B$.

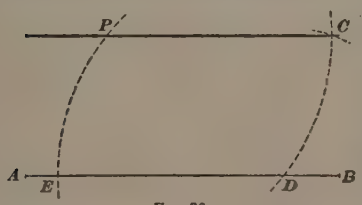


Fig. 36

38. These four problems form Plate I. They should be carefully and accurately drawn in with lead-pencil lines and then inked in. It will be seen that on Plate I, and Figs. 31 to 36, the given lines are *light*, the required lines *heavy*, and the construction lines, which in a practical working drawing would be left out, are *light dotted*. This system must also be followed in the four plates which are to follow. A single glance enables one to see at once the reason for drawing the figure, and the eye is directed immediately to the required line.

39. In the first five plates, accuracy and neatness are the main things to be looked for. The lines should be of *precisely*

the lengths specified in the description. When drawing a line through two points, be sure that the line goes through the points; if it does not pass exactly through the points, erase it and draw it again. If a line is supposed to end at some particular point, make it end there—do not let it extend beyond or fall short. Thus, in Fig. 36, if the line $P\,C$ does not pass through the points P and C, it is not parallel to $A\,B$. By paying careful attention to these points, a great deal of trouble will be avoided.

First ink in all the light lines and light dotted lines (which have the same thickness); then ink in the heavy required lines after the pen has been readjusted. Now do the lettering (first read carefully the paragraphs under the head "Lettering"), and finally draw the heavy border lines, which should be thicker than any other line on the drawing. The word "Plate" and its number should be printed at the top of the sheet, outside the border lines, and midway of its length, as shown. The student's name, followed by his class letters and number, should be printed in the lower right-hand corner below the border line. The date on which the drawing was completed should be placed in the lower left-hand corner, below the border line. *All of this lettering is to be in capitals $\frac{3}{32}''$ high.* Erase the division lines, and clean the drawing by rubbing very gently with the eraser. Care must be exercised when doing this, or the inked lines will also be erased.

It is best to use a so-called "sponge rubber" for this purpose, as it will not injure the inked lines. *If any part of a line has been erased or weakened, it must be redrawn.* Then write with the lead pencil your name and address in full on the back of your drawing, after which put your drawing in the empty tube which was sent you, and send it to the Schools.

HINTS FOR PLATE I

40. Do not forget to make a distinction between the width of the given and required lines, nor forget to make the construction lines dotted.

When drawing dotted lines, take pains to make the dots and spaces uniform in length. Make the dots about $\frac{1}{16}''$ long and the spaces only about one-third the length of the dots.

Try to get the work accurate. The constructions must be accurate, and all lines or figures should be drawn of the length or size previously stated. To this end, work carefully and keep the pencil leads very sharp, so that the lines will be fine.

The lettering on the first few plates, as well as on the succeeding plates, is fully as important as the drawing, and should be done in the neatest possible manner. Drawings sent in for correction with the lettering omitted will be returned for completion.

The reference letters like *A*, *B*, *C*, etc., as shown in Fig. 31, are not to be put on the plates.

Do not neglect to trim the plates to the required size. Do not punch large holes in the paper with the dividers or compasses. Remember that the division lines are to be erased, not inked in.

PLATE II

41. Draw the division lines in the same manner as described for Plate I. The following five problems, 5 to 9, inclusive, are to be drawn in regular order, as was done in Plate I, with problems from 1 to 4. The letter headings are given in heavy-faced type after the problem number.

Problem 5.—To bisect a given angle.*

Case I.—*When the sides intersect within the limits of the drawing.* See Fig. 37.

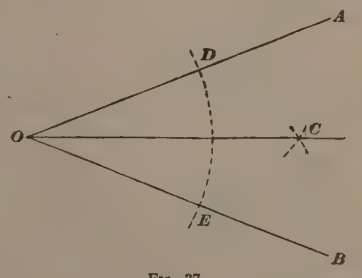


Fig. 37

Construction. — Let *A O B* be the angle to be bisected. Draw the sides *O A* and *O B* $3\frac{1}{2}''$ long. With the vertex *O* as a centre, and any convenient radius, describe an arc *D E* intersecting *O A* at *D* and *O B* at *E*. With *D* and *E* as centres, and a radius greater than the chord of half the

* Since the letter heading in this problem is very short, it will be better to place it over each of the two cases separately, instead of running it over the division line, as was done with the long headings of the two cases in Plate I. Put Case I and Case II under the heading, as in the previous plate.

arc $D\,E$, describe two arcs intersecting at C. The line drawn through C and O will bisect the angle; that is, $A\,O\,C = C\,O\,B$.

Case II.—*When the sides do not intersect within the limits of the drawing.* See Fig. 38.

CONSTRUCTION.—Draw two lines, $A\,B$ and $C\,D$, each $3\frac{1}{2}''$ long, and inclined towards each other as shown. With any point E on $C\,D$ as a centre, and any convenient radius, describe arc $F\,I\,G\,H$; with G as a centre and same radius, describe arc $H\,L\,E\,F$, intersecting $F\,I\,G\,H$ in H and F. With L as a centre and same radius, describe arc $K\,G\,J$, with I as a centre

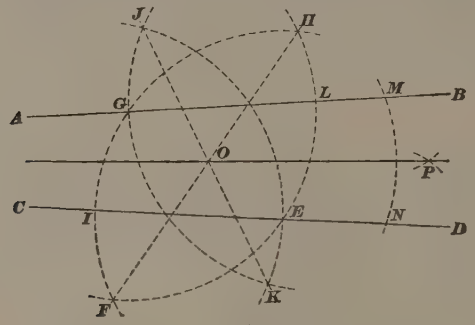


FIG. 38

and same radius, describe arc $J\,E\,K$, intersecting $K\,G\,J$ in K and J. Draw $H\,F$ and $J\,K$; they intersect at O, a point on the bisecting line. With O as a centre, and the same or any convenient radius, describe an arc intersecting $A\,B$ and $C\,D$ in M and N. With M and N as centres, and any radius greater than one-half $M\,N$, describe arcs intersecting at P. A line drawn through O and P is the required bisecting line.

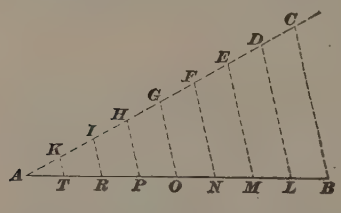


FIG. 39 (*a*)

Problem 6.—To divide a given straight line into any required number of equal parts.

See Fig. 39 (*a*).

CONSTRUCTION. — $A\,B$ is the given line $3\frac{7}{16}''$ long. It is required to divide it into eight equal parts. Through one

extremity A of the line draw an indefinite straight line $A\,C$, making any angle with $A\,B$. Set the dividers to any convenient distance, and space off eight equal divisions on $A\,C$, as $A\,K$, $K\,I$, $I\,H$, etc. Join C and B by the straight line $C\,B$, and through the points D, E, F, G, etc., draw lines $D\,L$, $E\,M$, etc., parallel to $C\,B$, by using the two set-squares; these parallels intersect $A\,B$ in the points L, M, N, etc., which are equally spaced along $A\,B$. The spaces $L\,M$, $M\,N$, $N\,O$, etc., are each equal to $\frac{1}{8}$ $A\,B$. If it had been desired to divide $A\,B$ into 10 equal parts, ten equal divisions would have been laid off on $A\,C$, and parallels drawn from the points of division, as before; and so on for any number of equal parts into which $A\,B$ is to be divided.

Another method is shown in Fig. 39 (*b*). Draw $A\,B$ as before, and erect the perpendicular $B\,C$. Now divide the length of $A\,B$ by the number denoting the number of equal parts into which $A\,B$ is to be divided, obtaining, in this case, $3\frac{7}{16}'' \div 8 = \frac{55}{128}''$. As $A\,C$ is longer than $A\,B$, the equal divisions $A\,K$, $K\,I$, etc., are longer than $A\,T$, $T\,R$, etc., and may be made any convenient length greater than $A\,B \div 8$. In this case, $\frac{1}{2}''$ is the most convenient fraction nearest to and greater than $\frac{55}{128}''$; hence, consider $A\,K$, $K\,I$, etc., to be each $\frac{1}{2}''$ in length, thus making the length of $A\,C$ $8 \times \frac{1}{2}'' = 4''$. With A as a centre, and a radius equal to $4''$, describe an arc cutting $B\,C$ in C, and draw $A\,C$. Then with a scale lay off $A\,K = K\,I =$ etc. $= \frac{1}{2}''$, and project K, I, H, etc., upon $A\,B$, in T, R, P, etc., the required points. The advantage of this method over the other is that the T square and set-square can be used throughout, thus making it very much easier to draw the parallels $D\,L$, $E\,M$, etc.

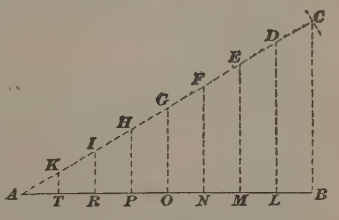


Fig. 39 (*b*)

When drawing this plate, either of the two methods given in this problem may be used.

Problem 7.—To draw a straight line through any given point on a given straight line to make any required angle with that line.

CONSTRUCTION.—In Fig. 40, $A\,B$ is the given line $3\frac{1}{2}''$ long, P is the given point, and $E\,O\,F$ is the given angle. With the vertex O as a centre, and any convenient radius, describe an arc $E\,F$ cutting $O\,E$ and $O\,F$ in E and F. With P as a centre, and the same radius, describe an arc $C\,D$. With D as a centre, and a radius equal to the chord of the arc $E\,F$, describe an arc cutting $C\,D$ in C. A line drawn through the points P and C will make an angle with $A\,B$ equal to the angle O, or $C\,P\,D = E\,O\,F$.

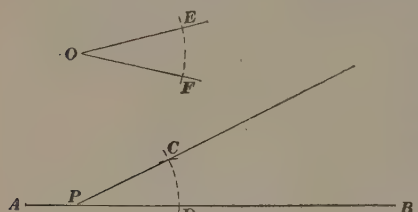


FIG. 40

Problem 8.—To draw an equilateral triangle, one side being given.

CONSTRUCTION.—In Fig. 41, $A\,B$ is the given side $2\frac{1}{2}''$ long. With $A\,B$ as a radius, and A and B as centres, describe two arcs intersecting in C. Draw $C\,A$ and $C\,B$, and $C\,A\,B$ is an equilateral triangle.

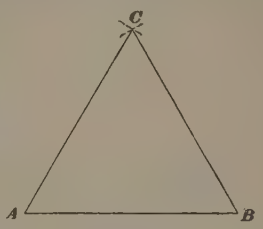


FIG. 41

Problem 9.—The altitude of an equilateral triangle being given, to draw the triangle.

CONSTRUCTION.—In Fig. 42, $A\,B$ is the altitude $2\frac{1}{4}''$ long. Through the extremities of $A\,B$ draw the parallel lines $C\,D$ and $E\,F$ perpendicular to $A\,B$. With B as a centre, and any convenient radius, describe the semicircle $C\,H\,K\,D$ intersecting $C\,D$ in C and D. With C and D as centres, and the same radius, describe arcs cutting the semicircle in H and K. Draw $B\,H$ and $B\,K$, and prolong them to

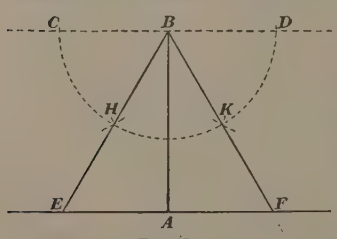


FIG. 42

meet $E F$ in E and F. $B E F$ is the required equilateral triangle.

This problem finishes Plate II. The directions for inking in, lettering, etc., are the same as for Plate I.

PLATE III

42. This plate is to be divided up like Plates I and II, and the six following problems are to be drawn in a similar manner:

Problem 10.— Two sides and the included angle of a triangle being given, to construct the triangle.

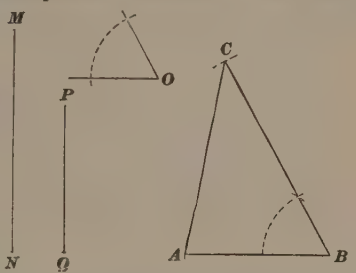


FIG. 43

CONSTRUCTION. — In Fig. 43, the given sides $M N$ and $P Q$ are $2\frac{1}{2}''$ and $1\frac{7}{8}''$ long, respectively. Let O be the given angle. Draw $A B$, and make it equal in length to $P Q$. Make the angle $C B A$ equal to the given angle O, and make $C B$ equal in length to the line $M N$. Draw $C A$, and $C A B$ is the required triangle.

Problem 11.—To draw a parallelogram when the sides and one of the angles are given.

CONSTRUCTION.—In Fig. 44, make the given sides $M N$ $2\frac{1}{2}''$ long and $P Q$ $1\frac{7}{8}''$ long. Let O be the given angle. Draw $A B$ equal to $M N$, and draw $B C$, making an angle with $A B$ equal to the given angle O. Make $B C$ equal to $P Q$. With C as a centre, and a radius equal to $M N$, describe an arc at D. With A as a centre, and a radius equal to $P Q$, describe an arc intersecting the other arc in D. Draw $A D$ and $C D$, and $A B C D$ is the required parallelogram.

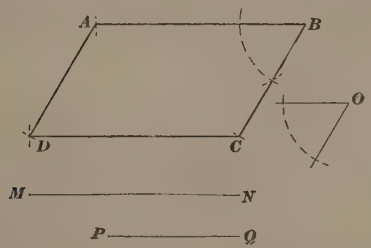


FIG. 44

Problem 12.—An arc and its radius being given, to find the centre.

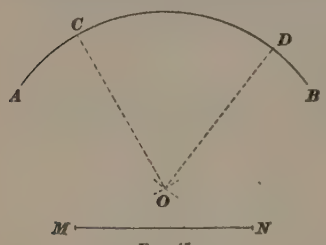


Fig. 45

Construction.—In Fig. 45, $A\,C\,D\,B$ is the arc, and $M\,N$, $1\frac{3}{4}''$ long, is the radius. With $M\,N$ as a radius, and any point C in the given arc as a centre, describe an arc at O. With any other point D in the given arc as a centre, and the same radius, describe an arc intersecting the first in O. O is the required centre.

Problem 13.—To pass a circumference through any three points not in the same straight line.

Construction.—In Fig. 46, A, B, and C are the given points. With A and B as centres, and any convenient radius, describe arcs intersecting each other in K and I. With B and C as centres, and any convenient radius, describe arcs intersecting each other in D and E. Through I and K and through D and E, draw lines intersecting at O. With O as a centre, and $O\,A$ as a radius, describe a circle; it will pass through A, B, and C.

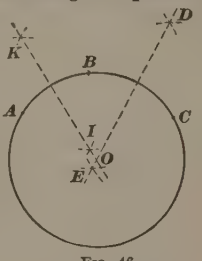


Fig. 46

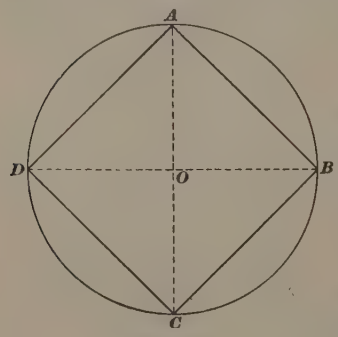


Fig. 47

Problem 14.—To inscribe a square in a given circle.

Construction.—In Fig. 47, the circle $A\,B\,C\,D$ is $3\frac{1}{2}''$ in diameter. Draw two diameters, $A\,C$ and $D\,B$, at right angles to each other. Draw the lines $A\,B$, $B\,C$, $C\,D$, and $D\,A$, joining the points of intersection of these diameters with the circumference of the circle, and they will be the sides of the square.

Problem 15.—To inscribe a regular hexagon in a given circle.

CONSTRUCTION.—In Fig. 48, from O as a centre, with the compasses set to $1\frac{3}{4}''$, describe the circle $A\,B\,C\,D\,E\,F$. Draw the diameter $D\,O\,A$, and from the points D and A, with the compasses set to the radius of the circle, describe arcs intersecting the circle at E, C, F, and B. Join these points by straight lines, and they will form the sides of the hexagon. This problem completes Plate III.

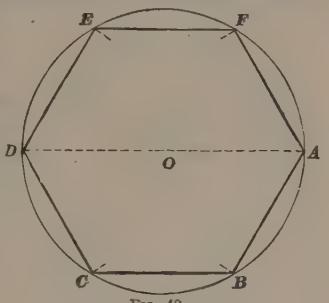


FIG. 48

PLATE IV

43. The first four problems on this plate are more difficult than any on the preceding plates and will require very careful construction. All the sides of each polygon must be of exactly the same length, so that they will space around evenly with the dividers. The figures should not be inked in until the pencil construction is done accurately. The preliminary directions for this plate are the same as for the preceding ones.

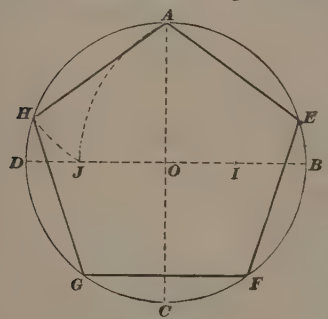


FIG. 49

Problem 16.—To inscribe a regular pentagon in a given circle.

CONSTRUCTION.—In Fig. 49, from O as a centre, with the compasses set to $1\frac{3}{4}''$, describe the circle $A\,B\,C\,D$. Draw the two diameters $A\,C$ and $D\,B$ at right angles to each other. Bisect one of the radii, as $O\,B$, at I. With I as a centre, and $I\,A$ as a radius, describe the arc $A\,J$ cutting $D\,O$ at J. With A as a centre, and $A\,J$ as a radius, describe an arc $J\,H$ cutting the circumference at H. The chord $A\,H$ is one side of the pentagon.

Problem 17.—To inscribe a regular octagon in a given circle.

CONSTRUCTION.—In Fig. 50, from *O* as a centre, with the compasses set to $1\frac{3}{4}''$, describe the circle *A B C D E F G H*. Draw the two diameters *A E* and *G C* at right angles to each other. Bisect one of the four equal arcs, as *A G* at *H*, and draw the diameter *H O D*. Bisect another of the equal arcs, as *A C* at *B*, and draw the diameter *B O F*. Straight lines drawn from *A* to *B*, from *B* to *C*, etc., will form the required octagon.

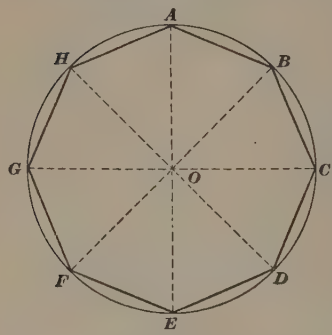


FIG. 50

Problem 18.—To inscribe a regular polygon of any number of sides in a given circle.

CONSTRUCTION.—In Fig. 51, from *O* as a centre, with the compasses set to $1\frac{3}{4}''$, describe the circle *A 7 C D*. Draw the two diameters *D 7* and *A C* at right angles to each other. Divide the diameter *D 7* into as many equal parts as the polygon has sides (in this case seven). Prolong the diameter *A C* and make *3′ A* equal to three-fourths of the radius *O A*. Through *3′* and *2*, the second division from *D* on the diameter *D 7*, draw the line *3′ I*, cutting the circumference at *I*. Draw the chord *D I*, and it is one side of the required polygon. The others may be spaced off round the circumference.

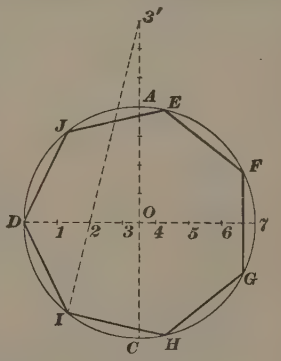


FIG. 51

Problem 19.—The side of a regular polygon being given, to construct the polygon.

CONSTRUCTION.—In Fig. 52, let *A C* be the given side. If the polygon is to have eight sides, the line *A C* should be, for

this plate, $1\frac{1}{4}''$ long. Produce *A C* to *B*. From *C* as centre, with a radius equal to *C A*, describe the semicircle *A 1 2 3 4 5 6 7 B*, and divide it into as many equal parts as there are sides in the required polygon (in this case eight). From the point *C*, and through the second division from *B*, as *6*, draw the straight line *C 6*. Bisect the lines *A C* and *C 6* by perpendiculars intersecting in *O*. From *O* as a centre, and with *O C* as a radius, describe the circle *C A H G F E D 6*. From *C*, and through the points *1, 2, 3, 4, 5* in the semicircle, draw lines *C H*, *C G*, *C F*, etc., meeting the circumference. Joining the points *6* and *D*, *D* and *E*, *E* and *F*, etc., by straight lines, will complete the required polygon.

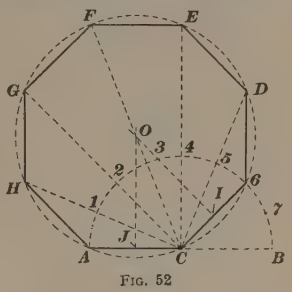


FIG. 52

Problem 20.—To find an arc of a circle having a known radius, which shall be equal in length to a given straight line.

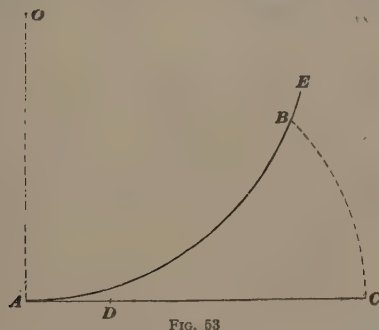


FIG. 53

NOTE.—There is no exact method, but the following approximate method is close enough for all practical purposes, when the required arc does not exceed $\frac{1}{4}$ of the circumference.

CONSTRUCTION.—In Fig. 53, let *A C* be the given line $3\frac{1}{2}''$ long. At *A*, erect the perpendicular *A O*, and make it equal in length to the given radius, say 4" long. With *O A* as a radius, and *O* as a centre, describe the arc *A B E*. Divide *A C* into four equal parts, *A D* being the first of these parts, counting from *A*. With *D* as a centre, and a radius *D C*, describe the arc *C B* intersecting *A B E* in *B*. The length of the arc *A B* very nearly equals the length of the straight line *A C*.

Problem 21.—An arc of a circle being given, to find a straight line of the same length.

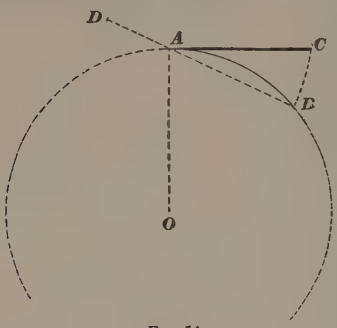


Fig. 54

This is also an approximate method, but close enough for practical purposes when the arc does not exceed $\frac{1}{6}$ of the circumference.

Construction.—In Fig. 54, let *A B* be the given arc; find the centre *O* of the arc, and draw the radius *O A*. For this problem, choose the arc so that the radius will not exceed $1\frac{3}{4}''$. At *A*, draw *A C* perpendicular to the radius (and, of course, tangent to the arc). Draw the chord *A B*, and prolong it to *D*, so that *A D* = $\frac{1}{2}$ the chord *A B*. With *D* as a centre, and a radius *D B*, describe the arc *B C* cutting *A C* in *C*. *A C* will be very nearly equal to the arc *A B*.

PLATE V

44. On this plate there are five problems instead of six. It should be divided into six equal parts or divisions, as the previous ones. The two right-hand end divisions are used to draw in the last figure of Plate V, which is too large to put in one division.

Problem 22.—To draw an egg-shaped oval.

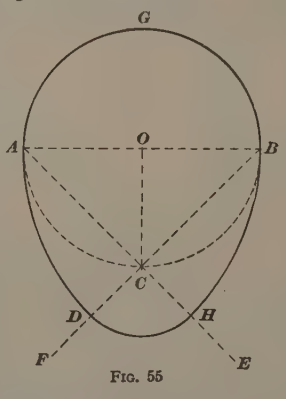


Fig. 55

Construction.—In Fig. 55, on the diameter *A B*, which is $2\frac{3}{4}''$ long, describe a circle *A C B G*. Through the centre *O*, draw *O C* perpendicular to *A B*, cutting the circumference *A C B G* in *C*. Draw the straight lines *B C F* and *A C E*. With *B* and *A* as centres, and the diameter *A B* as a radius,

describe arcs terminating in D and H, the points of intersection with $B\,F$ and $A\,E$. With C as a centre, and $C\,D$ as a radius, describe the arc $D\,H$. The curve $A\,D\,H\,B\,G$ is the required oval.

Problem 23.—To draw an ellipse the diameters being given. The exact method.

Construction.—In Fig. 56, let $B\,D$, the long diameter, or major axis, which is $3\frac{1}{2}''$ long, and $A\,C$, the short diameter, or minor axis, which is $2\frac{1}{4}''$ long, intersect at right angles to each other in the centre O, so that $D\,O = O\,B$ and $A\,O = O\,C$. With O as a centre, and $O\,C$ as a radius, describe a circle; with the same centre, and $O\,D$ as a radius, describe another circle. Divide both circles into the same number of parts. This is best done by first dividing the larger circle into the desired number of parts, beginning at the point B and laying off the points a, b, c, d, etc., and then drawing radial lines from the points of division on this circle to the centre O of the circles. These radial lines will cut the smaller circle at a', b', c', d', etc., and will divide it into the same number of parts as the larger one contains. Through the points of division on the smaller circle, draw horizontal lines, and, through the points of division on the larger circle, draw vertical lines; the points of intersection of these lines are points on the ellipse. Thus the horizontal line $a'\,e$ and the vertical line $a\,e$ intersecting at e give the point e of the ellipse. The horizontal line $b'f$ and the vertical line $b\,f$ intersect at f, a second point on the ellipse. In the same way, locate g, h, etc. Trace a curve through the points thus found by placing a French curve on the drawing in such a manner that one of its bounding lines will pass through three or more points, judging with the eye whether the curve so traced bulges out too much or is too flat. Then adjust the curve again, so that its bounding line will pass through several

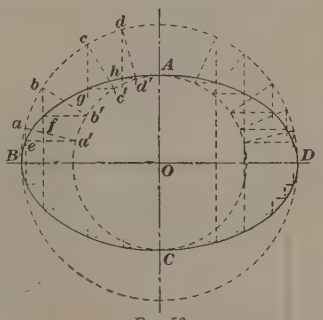


Fig. 56

more points, and so on, until the curve is completed. Care should be taken to make all changes in curvature as gradual as possible and all curves drawn in this manner should be drawn in pencil before being inked in. It requires considerable practice to be able to draw a good curved line in this manner by means of a French curve, and the general appearance of a curve thus drawn depends a great deal upon judgment and accuracy.

Problem 24.—To draw an ellipse by circular arcs.

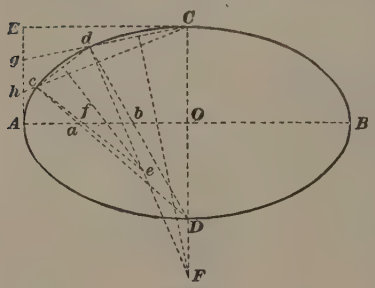


FIG. 57

CONSTRUCTION. — In Fig. 57, lay off the axes $A\,B$ and $C\,D$ of the same lengths as in the previous problem. Draw $A\,E$ parallel and equal to $O\,C$, and divide it into three equal parts by points at g and h. Divide $A\,O$ into three equal parts, as at a and b. Draw $C\,g$ and $C\,h$, and from D through a and b draw $D\,c$ and $D\,d$ cutting the lines $C\,g$ and $C\,h$ at c and d. Bisect $C\,d$ by a perpendicular line, and continue this perpendicular until it meets $C\,D$, produced, at F. Then draw $F\,d$. Next, draw $c\,d$, and bisect it with a perpendicular intersecting $F\,d$ at e. Draw $e\,c$, cutting $A\,O$ in f. Then, with F as a centre, draw the arc $C\,d$; with e as a centre draw the arc $d\,c$; and with f as a centre draw the arc $c\,A$. The outline of the ellipse from A to C is thus determined. As the ellipse is a symmetrical figure, the parts $C\,B$, $B\,D$, and $D\,A$ of the outline are like $A\,C$, and are drawn in a similar manner.

Problem 25.—To draw a parabola, the axis and longest double ordinate being given.

EXPLANATION.—The curve shown in Fig. 58 is called a **parabola.** This curve and the ellipse are the bounding lines of certain sections of a cone. The line $O\,A$, which bisects the area included between the curve and the line $B\,C$, is called the **axis.** Any line, $B\,A$ or $A\,C$, drawn perpendicular to $O\,A$, and whose length

is included between *O A* and the curve, is called an **ordinate.** Any line, as *B C*, both of whose extremities rest on the curve, and is perpendicular to the axis, is called a **double ordinate.** The point *O* is called the **vertex.**

CONSTRUCTION.—Make the axis *O A* equal to $3\frac{1}{2}''$, and the longest double ordinate *B C* equal to 3″. *B A*, of course, equals *A C*. Draw *D E* through the other extremity of the axis and perpendicular to it; also draw *B D* and *C E* parallel to *O A* and intersecting *D E* in *D* and *E*. Divide *D B* and *A B* into the same number of equal parts, as shown (in this case six); through the vertex *O*, draw *O 1*, *O 2*, etc., to the points of division on *D B*,

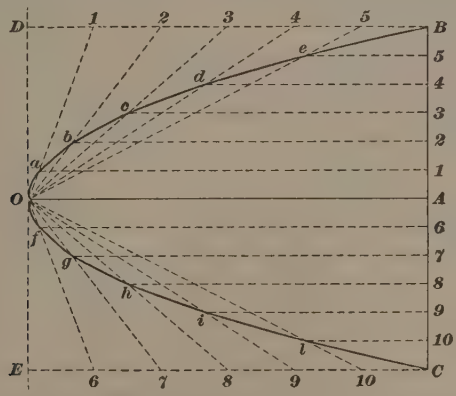


FIG. 58

and through the corresponding points *1*, *2*, etc., on *A B* draw lines parallel to the axis. The points of intersection of these lines, *a*, *b*, *c*, etc., are points on the curve, through which it may be traced. In a similar manner, draw the lower half *O f g h i l C* of the curve.

Problem 26.—To draw a helix, the pitch and the diameter being given.

EXPLANATION.—The helix is a curve formed by a point moving round the cylinder and at the same time advancing along its length a certain distance; this forms the winding curved line shown in Fig. 59. The centre line *A O*, drawn through the

cylinder, is called the **axis** of the helix, and any line perpendicular to the axis and terminated by the helix is of the same length, being equal to the radius of the cylinder. The distance *B 12* that the point advances lengthways during one revolution is called the **pitch.**

CONSTRUCTION.—As mentioned before, this figure occupies two spaces of the plate. The diameter of the cylinder is $3\frac{1}{2}''$, the pitch is $2''$, and a turn and a half of the helix is to be shown. The rectangle *F B E D* is a side view of the cylinder, and the circle *1′, 2′, 3′, 4′*, etc., is a bottom view. It will be noticed that one-half of a turn of the helix is shown dotted; this is because that part of it is on the other side of the cylinder, and cannot be seen. Lines that are hidden are drawn dotted. Draw the axis *O A* in the centre of the space. Draw *F D* $3\frac{1}{2}''$ long and $4''$ from the top border line; on it construct a rectangle whose height *F B* = $3''$. Take the centre *O* of the circle $2\frac{3}{4}''$ below the point *H* on the axis *A O*, and describe a circle having a diameter of $3\frac{1}{2}''$, equal to the diameter of the cylinder. Lay off the pitch from *B* to *12* equal to $2''$, and divide it into a convenient number of equal parts (in this case 12), and divide the circle into the same number of equal parts, beginning at one extremity of the diameter *12′ O 6′*, drawn parallel to *B E*. At

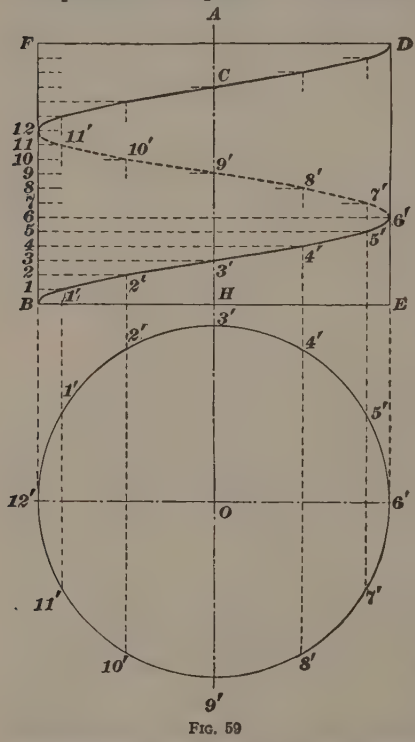


FIG. 59

the point *1′* on the circle divisions, erect *1′–1′* perpendicular to *B E*; through the point *1* of the pitch divisions, draw *1–1′* parallel to *B E*, intersecting the perpendicular in *1′*, which is a point on the helix. Through the point *2′*, erect a perpendicular *2′–2′*, intersecting *2–2′* in *2′*, which is another point on the helix. So proceed until the point *6* is reached; from this point to the point *12* of the helix, the curve will be dotted. It will be noticed that the points of division *7′*, *8′*, *9′*, *10′*, and *11′* on the circle are directly opposite the points *5′*, *4′*, *3′*, *2′*, and *1′*; hence, it was not necessary to draw the lower half of the circle, since the point *5′* could have been the starting point, and the operation could have been reversed to find the points on the dotted half of the helix. The other full curved line of the helix can be drawn in the same manner as the first half.

This ends the subject of practical geometry. Mechanical drawing, or the representation of objects on plane surfaces, will now be commenced.

THE REPRESENTATION OF OBJECTS

45. There are five kinds of lines used in drawing, thus:

The light full line.

The dotted line.

The dash-and-dot line.

The dash line.

The heavy full line.

The light full line is used the most; it is used for drawing the outlines of figures, and all other parts that can be seen by the eye.

The dotted lined, consisting of a series of very short dashes, is used in showing the position and shape of that part of the object represented by the drawing which is concealed from the eye in the view shown; for example, a hollow prism closed on all sides. The hollow part cannot be seen; hence its size, shape, and position are represented by dotted lines.

The dash-and-dot line, consisting of a dash and a dot repeated regularly, is used to indicate the centre lines of the figure or parts of the figure, and also to indicate where a section has been taken when a sectional view is shown. This line is sometimes used for construction lines in geometrical figures.

The dash line, consisting of a series of dashes, is used in putting in the dimensions, and serves to prevent the dimension lines from being mistaken for lines of the drawing.

The heavy full line is made not less than twice as thick as the light full line, and is used for shade lining.

Further explanations in regard to these lines will be given when the necessity for using them arises.

46. The illustration in Fig. 60 shows a rectangular block with one of its corners cut away and with a cylindrical hole extending through it from the upper surface to the lower. All the adjacent surfaces of this block meet at right angles, and consequently all of the adjacent edges are at right angles to one another. If the angles in the illustration are actually measured, however, it will be found that they are not right angles. The reason for this is that the figure represents a perspective view, or a view of the object as it would appear to the eye of an observer in a certain position. For the same reason, the top of the hole in the drawing is elliptical instead of round. Furthermore, the edges *A D*, *B C*, *L M*, *I K*, *F G*, and *E H*, which are of the same length on the object itself, will be found unequal if measured directly on the drawing.

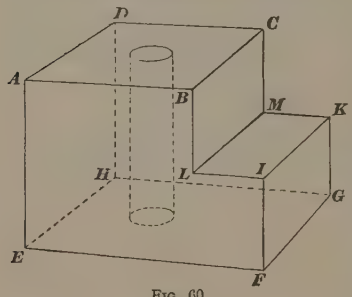


FIG. 60

The actual length of a line in such a drawing as this can be determined only by a person familiar with perspective drawing, and then only with difficulty. While a perspective drawing clearly indicates the appearance of an object, it is useless in

showing all of the actual dimensions. In order to represent an object in such a manner that any line or angle can be measured directly and accurately, what is termed a **projection drawing,** or **orthographic projection,** is universally employed.

In the perspective drawing in Fig. 60, five of the eight surfaces of the block are visible to the observer, and are therefore bounded by light, full lines. The other three faces are hidden from view, and their bounding lines are therefore shown dotted. Similarly, the upper outline of the hole can be seen, and it is therefore shown by a full line, while the lower outline and the sides of the hole, being hidden from view, are indicated by dotted lines.

47. A line or surface is *projected* upon a plane, by drawing perpendicular lines from points on the line or surface to the plane and joining them.

Thus, if perpendiculars are drawn from the extremities of a line, as $A\,B$, to another line $H\,K$, as shown in Fig. 61, that portion of $H\,K$ included between the feet of these perpendiculars is called the **projection** of $A\,B$ upon $H\,K$.

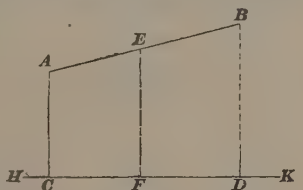


FIG. 61

Thus, $C\,D$ is the projection of $A\,B$ upon $H\,K$, the point C is the projection of the point A upon $H\,K$, and the point D is the projection of the point B upon $H\,K$.

The projection of any point of $A\,B$, as E, can be found by drawing a perpendicular from E to $H\,K$, and the point where this perpendicular intersects $H\,K$ is its projection. In this case, the point F is the projection of the point E upon $H\,K$.

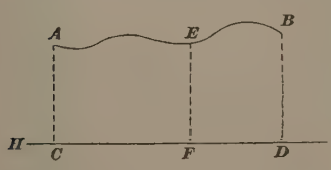


FIG. 62

It makes no difference whether the line is straight or curved, the method of finding the projection is exactly the same. See Fig. 62.

In a similar way, a surface is projected upon a flat surface.

Thus, it is desired to project the irregular surface *a b d c*, Fig. 63, upon the flat surface *A B D C*. Draw the lines *a a'*, *b b'* perpendicular to the flat surface; join the points *a'* and *b'*, where these perpendiculars intersect the flat surface *A B D C*, by a straight line *a' b'*, and *a' b'* is the projection of the line *a b* upon *A B D C*.

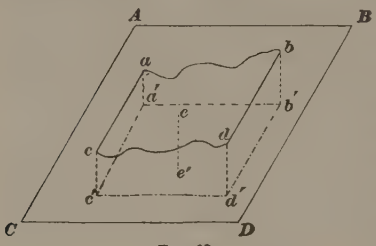


Fig. 63

In the same way, *a' c'* is found to be the projection of *a c*; *c' d'*, the projection of *c d*; and *d' b'*, the projection of *d b*. Hence, the projection of the irregular surface *a b d c* upon the flat surface *A B D C* is the quadrilateral *a' b' d' c'*.

The projection of any point, as *e*, is found, as before, by drawing a perpendicular from the point *e* to the surface; thus, *e'* is the projection of the point *e* upon the plane *A B D C*.

48. Suppose that the block, Fig. 60, were placed on a horizontal plane surface (a surface perfectly flat, like a surface plate), and the outline of the bottom were traced by passing a pencil along its edges, including the round hole, the result would look like Fig. 64, in which the rectangle *E F G H* represents the bottom of the block and the circle represents the hole. The angles and lengths of the edges on this drawing will be found to be exactly the same as they are on the block itself.

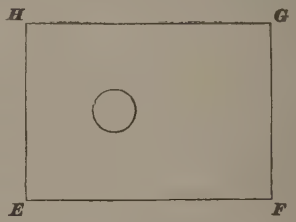


Fig. 64

The outline *E F G H*, Fig. 64, may then be said to represent the projection of the surface *E F G H*, Fig. 60, on a horizontal plane.

In a similar manner, a drawing might be made to represent the top. But this is unnecessary, as the top can be projected on Fig. 64, thus accomplishing both objects by the use of but one drawing. This combined drawing is shown in Fig. 65.

The edge $A\ D$ of the block is of the same length as the edge $E\ H$ and lies vertically above it. Hence, the projection of $A\ D$ on the horizontal plane coincides with $E\ H$, and the projections of both of these lines are represented by the line $A\ D$, Fig. 65. The edge $I\ K$ is equal in length to $F\ G$ and is vertically above it, so that $I\ K$, Fig. 65, represents the projections of both of these lines. The lines $B\ C$ and $L\ M$, also of equal lengths, lie in the same vertical plane, and their projections are represented in Fig. 65 by $B\ C$, in which B is the projection of the points B and L, and C is the projection of the points C and M. As the edges $A\ B$ and $L\ I$ are vertically above $E\ F$, their projection $A\ B\ I$, Fig. 65, coincides with the projection of $E\ F$; and similarly $D\ C\ K$, Fig. 65, represents the projections of $D\ C$ and $M\ K$, as well as that of $H\ G$. This drawing shows the figure as it would appear to the eye of an observer situated directly over it.

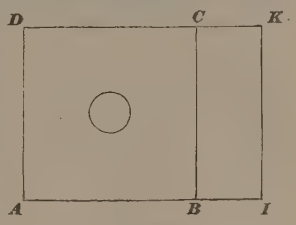


FIG. 65

49. A drawing which represents the object as if it were resting on a horizontal plane, and the observer looking at it from above, is called a **top view,** or **plan.** The line of vision is thus perpendicular to the faces $A\ B\ C\ D$ and $I\ K\ M\ L$ of the block. The lengths of $A\ B$, $B\ C$, etc., and the diameter of the hole, can be measured directly on this drawing. The drawing is not yet complete, however, since it does not show whether the ends and sides are round, hollowed out, or flat. For this purpose, two more views are necessary—a *front view,* commonly called a **front elevation,** and a *side view,* or **side elevation.** A front view, or front elevation, is drawn by imagining the eye to be so situated that the observer looks directly at the front of the object; a side view is drawn so as to represent the appearance of the object when observed from a point squarely opposite the side. The side looked at is then drawn as if it were projected on a vertical plane at right angles to the horizontal plane.

50. The front elevation of the block illustrated in Fig. 60 is shown in Fig. 66. An observer stationed squarely opposite the front face of the block will see only the surface *A B L I F E*, Fig. 60, and the lines *A B*, *B L*, *L I*, etc., when projected on a vertical plane, will give the outline *A B L I F E*, Fig. 66. The surface *D C M K G H* lies directly behind *A B L I F E*, and is of exactly the same shape and size, so that its projection on a vertical plane is also represented by *A B L I F E*, Fig. 66. The hole through the block cannot be seen from the front, and hence it is indicated by the two parallel dotted lines.

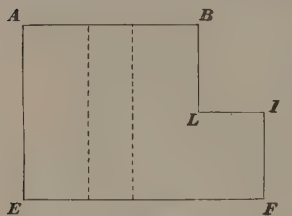


FIG. 66

The side view is shown in Fig. 67, and it is produced by assuming that the eye of the observer is at the right of the object in Fig. 60, directly opposite the edge *I K*. Viewed from this point, the surfaces *F G K I* and *B C M L* can be seen, and their projections on a vertical plane are represented by *F G K I* and *B C K I*, Fig. 67, the line *I K* being the projection of both *I K* and *L M*, Fig. 60. The vertical edge *A E* lies directly behind *B L* and *I F* when the block is viewed from the right, and is exactly equal to their combined length. Hence its projection is represented by *B I F*, Fig. 67. Similarly, the line *C K G*, Fig. 67, represents the projection of *D H* as well as that of *C M* and of *K G*. The horizontal line *L M*, Fig. 60, lies directly behind *I K*, and consequently their projections on the vertical plane are indicated by the horizontal line *I K*, Fig. 67. The hole is represented in this view by two vertical dotted lines because it cannot be seen by the eye of the observer.

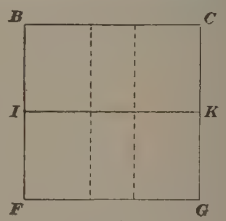


FIG. 67

51. The three views given in Figs. 65, 66, and 67 show all of the actual dimensions of the block illustrated in Fig. 60. For instance, the plan, Fig. 65, shows the diameter of the hole,

the total length of the block, its width, the length $D\,C$ of the top, and the width $C\,K$, which corresponds to the distance $M\,K$ in Fig. 60. The front elevation, Fig. 66, shows the total depth $A\,E$ of the block and the depth $B\,L$ and $I\,F$ of the parts by which the offset is formed. The side elevation, Fig. 67, also shows the width and depth of the block, and the distance of the horizontal line $I\,K$ from $B\,C$ indicates the depth at which the offset is formed.

52. In general, the shape and size of an object may be definitely shown by three views, namely, a plan, a front elevation,

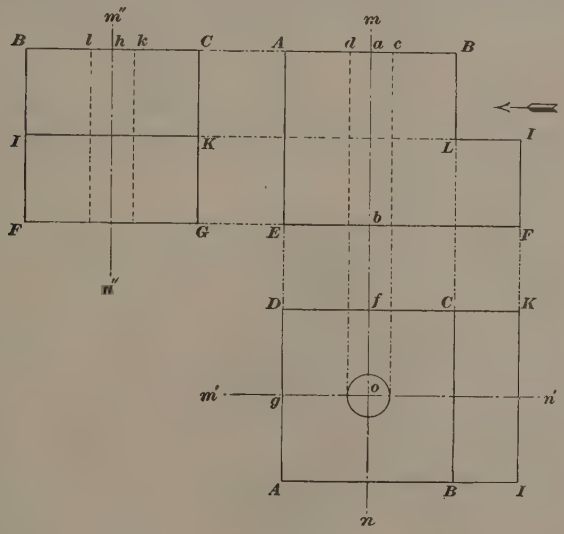


FIG. 68

and a side elevation. It is customary, therefore, to arrange these three views in conjunction with one another. Such an arrangement is illustrated in Fig. 68, which shows the three views of Figs. 65, 66, and 67 placed together. To avoid confusion, the three views are arranged on the drawing in a certain order; first, the plan; above it, the front elevation; and to the left of that, the side elevation. In making a drawing, it is immaterial

as to which view is drawn first. Sometimes it will be found desirable to begin with the plan, while in other cases it will be found more convenient to begin with one of the elevations. Also, the side elevation may be placed either to the left or to the right of the front elevation, depending on whether the object is viewed from the right or from the left.

53. The lines made up of dashes and dots are the **centre lines.** They serve to show the connection existing between the views of an object and to indicate the axes of cylindrical surfaces. It will be noticed that, in the plan, the two centre lines cross each other at right angles, and that their point of intersection is the centre of the circle which represents the hole. Whenever a circle is drawn, two centre lines should also be drawn through its centre at right angles to each other; this enables anyone looking at a drawing to instantly locate the centre of any circle. This remark also applies to ellipses, semi-circles, etc.

54. In order to indicate the method to be followed in producing a drawing, the successive steps in the formation of the views in Fig. 68 will be described. Assuming that the drawing is to be begun with the front elevation, draw a vertical centre line $m\,n$ of indefinite length, and on it lay off a distance $a\,b$ equal to the total depth $A\,E$ of the block shown in Fig. 60. Through the points a and b draw horizontal lines of indefinite length. On the horizontal through a lay off $a\,A$ and $a\,B$ each equal to half of the length $A\,B$ of the block in Fig. 60. Through A then draw a vertical line until it meets the horizontal line through b. This intersection will give the point E. Now, from E lay off $E\,F$ on the horizontal, making it equal to the total length $E\,F$ of the block, Fig. 60. Through B and F draw indefinite vertical lines, and on the vertical through F lay off $F\,I$ equal to the height $F\,I$ of the small end of the block shown in Fig. 60. Then draw a horizontal line through I, cutting the vertical through B at the point L. Finally, lay off $a\,c$ and $a\,d$ each equal to the radius of the hole in the block, and draw vertical dotted lines from c and d to meet the line $E\,F$. The front elevation is then complete.

55. Having the front elevation, it is a simple matter to construct the plan. First, continue the vertical lines $A\,E$, $B\,L$, and $I\,F$ of the front elevation downwards indefinitely. Through a point f on the centre line $m\,n$ draw a horizontal line, which will cut the vertical lines at D, C, and K. From D lay off $D\,A$ equal to the width $D\,A$ of the block, Fig. 60, and draw the horizontal line $A\,I$, cutting the vertical lines through C and K at B and I. Through the point g, midway between D and A, draw the horizontal centre line $m'\,n'$, cutting the vertical centre line at o. The point o is then the centre of the circle that represents the hole in the block. With o as a centre and a radius equal to $a\,c$ in the elevation, describe the circle shown. The vertical lines through d and c in the front elevation will, if continued downwards, be tangent to the circle. The plan is thus completed.

56. The side elevation yet remains to be drawn before the drawing is finished. To accomplish this, extend the horizontal lines $B\,A$ and $F\,E$ of the front elevation indefinitely to the left, and at some convenient point draw the vertical centre line $m''\,n''$. This centre line will cut the upper horizontal line at h. From h lay off $h\,C$ and $h\,B$ equal to $g\,A$ and $g\,D$ of the plan, and draw vertical lines from C and B, intersecting the horizontal through E at the points G and F. Next, lay off $h\,k$ and $h\,l$ equal to $a\,c$ and $a\,d$ in the front elevation and draw the vertical dotted lines through k and l. These lines represent the sides of the hole in the block. Finally, extend the horizontal line $I\,L$ of the front elevation. It will cut $C\,G$ and $B\,F$ at K and I, and the full line $I\,K$ will complete the elevation and the drawing. The arrow indicates the direction in which the object is viewed when constructing the side elevation from the given front elevation.

If the block had been viewed from the left, the side elevation would have been placed to the right of the front elevation in the drawing, instead of to the left, as shown. In such a case, the side elevation would have been unchanged in outline, but it would have been lettered differently. Also, the line corresponding to $I\,K$ would have been shown dotted, inasmuch as it would have been the projection of a hidden edge.

DRAWING PLATE, TITLE : PROJECTIONS I

57. In making actual drawings of objects when the size of the plate is limited, it is usually impossible to divide it up into a certain number of parts, as in the case of the preceding plates, for the various figures differ widely in size. These drawings should be so made that no part shall come nearer than $\frac{3}{4}''$ to the border line, and the figures should be so arranged as to present a pleasing appearance to the eye, and not be scattered aimlessly all over the drawing.

58. Fig. **1*** on the plate represents the three views of the rectangular prism illustrated in Fig. 69. In this case, the front elevation $A\ B\ D\ C$ is drawn first, and the plan and side elevation afterwards as was done in Fig. 68.

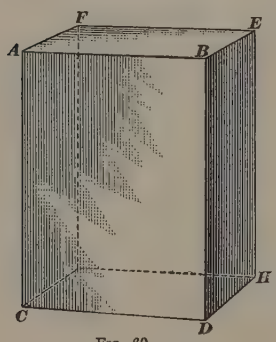


FIG. 69

To indicate why the three views occupy the relative positions shown, Fig. 70 is used. The surfaces $O\ X\ X_1\ Y$, $O\ Y\ Y_1\ Z$, and $O\ Z\ Z_1\ X$ are plane surfaces meeting at right angles to one another. The plane $O\ Z\ Z_1\ X$ is horizontal, and the other two are vertical. Suppose that in the angle formed by these three surfaces the prism shown in Fig. 69 is suspended so that its front $A\ B\ D\ C$ is parallel to $O\ X\ X_1\ Y$, its side $B\ E\ H\ D$ is parallel to $O\ Y\ Y_1\ Z$, and its end $F\ E\ B\ A$ is parallel to $O\ Z\ Z_1\ X$. Next, let the front $A\ B\ D\ C$ of the prism be projected on the plane $O\ X\ X_1\ Y$. To do this, lines are drawn from A, B, D, and C perpendicular to the plane $O\ X\ X_1\ Y$, as shown. These lines intersect the plane in the points A', B', D', and C', and if these points are then joined by straight lines, the outline $A'\ B'\ D'\ C'$ is produced. This is then the projection

* To distinguish the figures on the plates from those in the text, the figure numbers on the former are printed in heavier type, as here indicated.

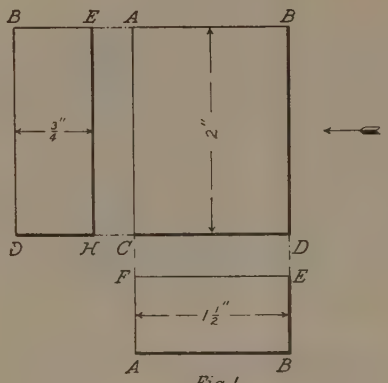


Fig. 1

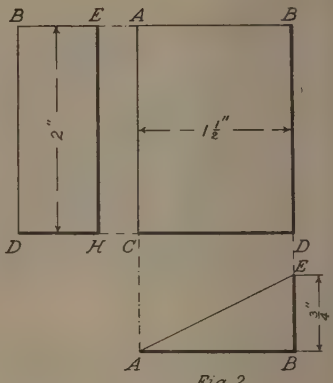


Fig. 2

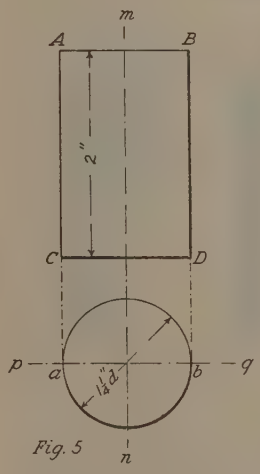


Fig. 5

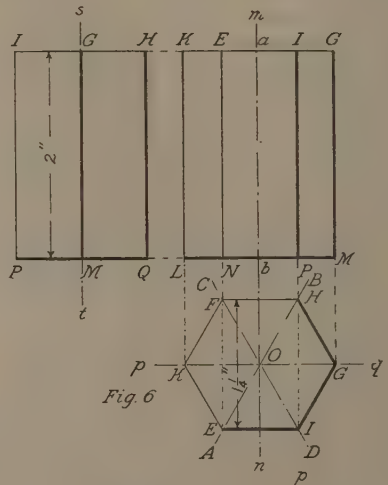


Fig. 6

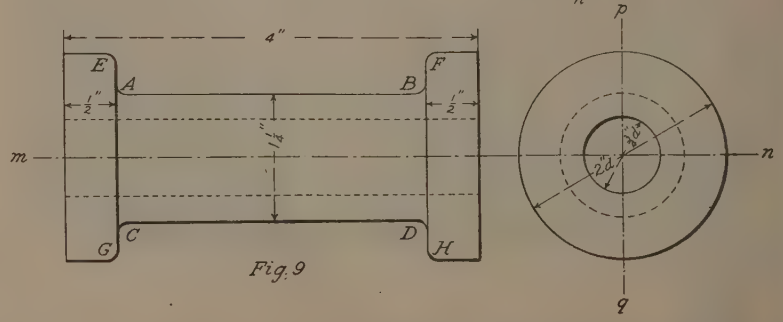


Fig. 9

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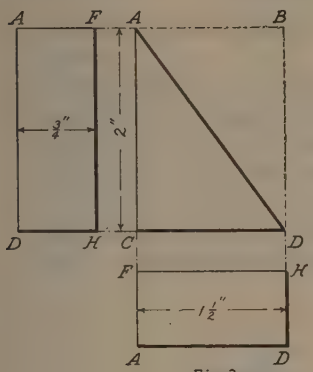


Fig. 3

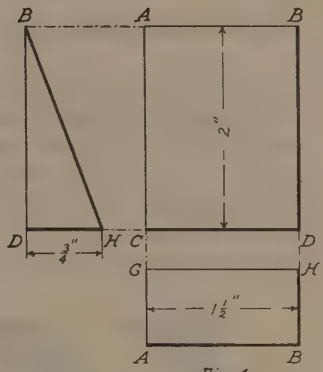


Fig. 4

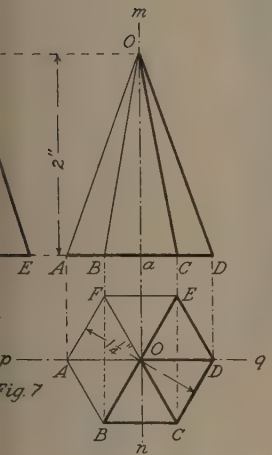


Fig. 7

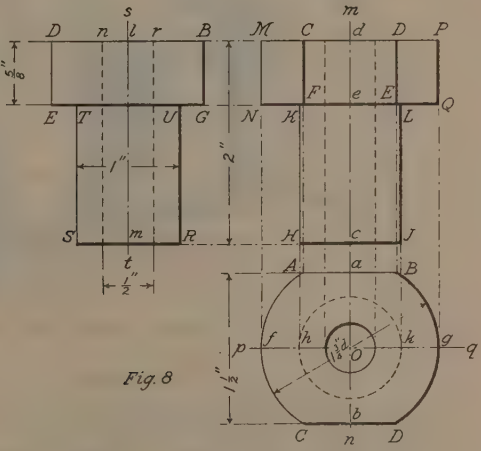


Fig. 8

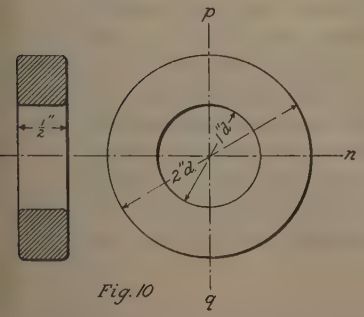


Fig. 10

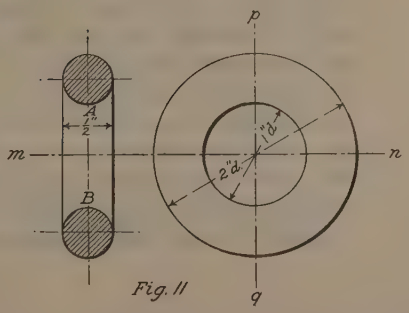


Fig. 11

mpany. Entered at Stationers' Hall, London. All rights reserved

of $A\ B\ D\ C$ on a vertical plane, or the front elevation of the prism.

In the same way, the side $B\ E\ H\ D$ and the end $F\ E\ B\ A$ are projected on the planes to which they lie parallel, giving the side elevation $B'\ E'\ H'\ D'$ on the vertical plane $O\ Y\ Y_1\ Z$ and the plan $F'\ E'\ B'\ A'$ on the horizontal plane $O\ Z\ Z_1\ X$.

The three views are now contained in three planes lying at right angles to each other. To bring the views into the same plane, suppose that the plane $O\ Y\ Y_1\ Z$ is cut away from the

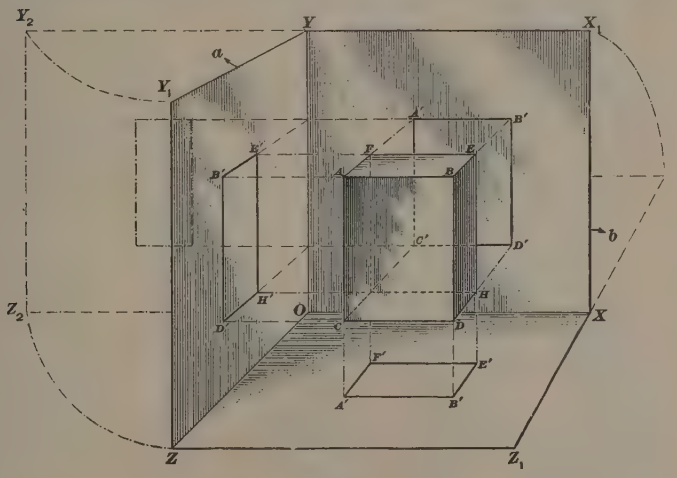


Fig. 70

plane $O\ Z\ Z_1\ X$ along the line $O\ Z$ and is folded back in the direction of the arrow a until it lies in the same plane as $O\ X\ X_1\ Y$. Its position will then be indicated by the dotted outline $O\ Y\ Y_2\ Z_2$. Next, suppose that these combined planes, indicated by $Y_2\ X_1\ X\ Z_2$, are folded backwards and downwards in the direction of the arrow b until they lie in the horizontal plane with $O\ Z\ Z_1\ X$. Then the three views of the prism will lie in one horizontal plane, and they will occupy the positions shown in Fig. **1** of the plate. The foregoing explanation will serve to indicate, graphically, why the side elevation

and the plan, respectively, lie to the left of, and below, the front elevation in the drawing.

59. In making the drawing shown in Fig. **1** of the plate, it is assumed that the prism is standing on one of its ends, with the broadside toward the observer. The prism is 2″ long, $1\frac{1}{2}$″ wide and $\frac{3}{4}$″ thick. Since the front elevation is to be drawn first, the first step is to draw two vertical parallel lines *A C* and *B D* at a distance of $1\frac{1}{2}$″ from each other, and then to draw *A B* horizontally. Next, lay off *A C* equal to 2″, and draw *C D* parallel to *A B*. This completes the front elevation, which is a rectangle 2″ by $1\frac{1}{2}$″.

To construct the plan, extend the lines *A C* and *B D* of the front elevation downwards indefinitely, and between the two lines thus produced draw the horizontal line *F E*, locating the points *F* and *E*. From *F* lay off *FA* equal to $\frac{3}{4}$″ and draw *A B* parallel to *F E*. It will cut the other vertical line at *B*. Joining *E* and *B* by a straight line, the plan is completed. It is a rectangle $1\frac{1}{2}$″ by $\frac{3}{4}$″.

To construct the side elevation, extend the lines *BA* and *D C* of the front elevation indefinitely to the left, and between the lines thus produced draw the vertical line *E H*. Lay off *E B* equal to $\frac{3}{4}$″, and from *B* draw *B D* parallel to *E H*. Join *H* and *D* by a straight line, and the rectangle thus completed is the side elevation. It measures 2″ by $\frac{3}{4}$″.

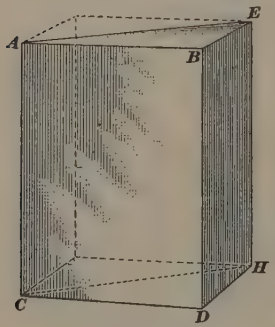


Fig. 71

Comparison of the successive steps just given with the methods of projection indicated in Fig. 70 will serve to make clear the reasons for the several operations.

60. In Fig. **2** of the plate are shown three views of the wedge illustrated in Fig. 71. This wedge is simply a triangular prism, standing on one of its triangular ends, and may be conceived as half of the prism shown in Fig. 69. In other words, if the rectangular prism in Fig. 69 were cut in

two vertically along the diagonal $A\ E$, the wedge shown in Fig. 71 would be produced.

In making the drawing, first draw the front elevation $A\ B\ D\ C$ and then the side elevation $B\ E\ H\ D$. The method of constructing these views is exactly the same as that used in constructing the corresponding views of the rectangular prism. The plan, however, is different. To draw it, extend the lines $A\ C$ and $B\ D$ downwards, and between them draw a horizontal line $A\ B$. From B, lay off $B\ E$ vertically, making it $\frac{3}{4}''$ long. Then join A and E by a straight line, giving the triangle $A\ E\ B$ as the plan of the wedge.

61. If the rectangular prism, Fig. 69, were cut through from front to back along the diagonal $A\ D$, a wedge like that in Fig. 72 would be produced. Evidently, a front elevation of this wedge will be a triangle. To obtain the front elevation in Fig. **3**, first draw two vertical lines $A\ C$ and $B\ D$ at a distance of $1\frac{1}{2}''$ from each other. From some point A on the first, lay off $A\ C$, making it $2''$ long. Draw the horizontal line $C\ D$, and connect A and D by a straight line: then $A\ D\ C$ is the desired elevation. It will be observed that the triangle $A\ D\ C$ is just half of the rectangle $A\ B\ D\ C$, this rectangle being the front elevation of the rectangular prism. The plan and the side elevation of the wedge in Fig. **3** are exactly like those of the rectangular prism and are drawn in the same way.

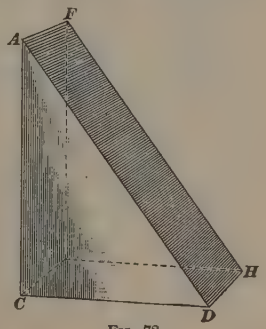


FIG. 72

62. If the rectangular prism is cut in two from side to side along the diagonal $B\ H$, the wedge shown in Fig. 73 will be produced. The plan and front elevation of this wedge are exactly like the corresponding views of the prism, and they are drawn in the same manner. They are shown in Fig. **4** of the plate. The side elevation, however, differs from that of the rectangular prism. To draw it, produce $B\ A$ and $D\ C$ horizontally, and

between the lines thus produced draw a vertical line $B\,D$. From D lay off $D\,H$ on the horizontal, making it $\frac{3}{4}''$ long, and draw $B\,H$.

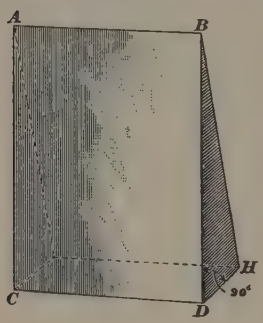


Fig. 73

The side elevation is thus a triangle, $D\,B\,H$, and is exactly half of the rectangle $D\,B\,E\,H$, Fig. **1**, representing the side elevation of the rectangular prism.

63. A comparison of Figs. **2**, **3**, and **4** with Fig. **1** will serve to show why three views of some objects are necessary in order to fully define their shapes. In Figs. **1** and **2**, the side elevations and front elevations are precisely alike, and if no other views were given it would be impossible to determine whether the objects represented by the two drawings were different or not. However, as soon as the plan of each is added, it is seen immediately that one is a rectangular prism and the other a triangular prism.

In Figs. **1** and **3**, the plans and side elevations are of exactly the same size and shape, but the front elevations differ, thereby indicating the difference between the two objects illustrated by the drawings.

Again, the front elevations and plans of Figs. **1** and **4** are alike, and no difference in the objects represented could be determined by these views alone. But, by adding the side elevation of each, the difference is at once shown clearly.

64. The views in Fig. **5** are the plan and front elevation of a cylinder $2''$ high and $1\frac{1}{4}''$ in diameter. In this instance, the plan is drawn first, as it is found most convenient to do so. First, the vertical centre line $m\,n$ is drawn, and then the horizontal centre line $p\,q$. With their intersection as a centre, and a radius of $\frac{5}{8}''$, a circle is drawn. This circle is the plan of the cylinder. Next, two vertical lines are drawn so as to be tangent to the circle at a and b. On the vertical through a, lay off $A\,C$ equal to $2''$, and from A and C draw horizontal lines meeting the vertical through b at the points B and D, respectively. Then, $A\,B\,D\,C$ is the front elevation required.

No side elevation is shown, for the simple reason that it is exactly like the front elevation, and therefore unnecessary.

65. Fig. **6** shows three views of a **hexagonal prism** 2″ long and $1\frac{1}{4}$″ thick, measured between parallel sides and not from edge to edge. A perspective of this prism is shown in Fig. 74. The plan in Fig. **6,** which is a regular hexagon, is drawn first. To begin, draw the two centre lines *m n* and *p q* at right angles to each other, intersecting at *O*.

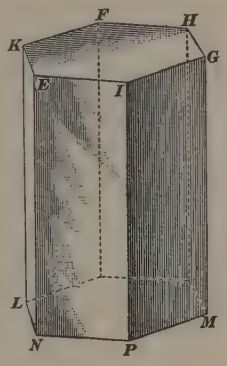


FIG. 74

With *O* as a centre, and a radius equal to one-half of the distance between two parallel sides, or $1\frac{1}{4}'' \div 2 = \frac{5}{8}''$, describe a circle. Now, use the **T** square to draw two horizontal lines through the points of intersection of this circle with the centre line *m n*. By means of the **T** square and 60° set-square, draw *A B* and *C D* through *O*, in such a manner that the angles *B O q* and *C O p* each equal 60° ; this is done by keeping the longer of the two short sides of the set-square vertical, and passing the pencil along the hypotenuse. Through *E* and *H*, the points of intersection of *A B* with the two parallel lines, draw *E K* and *H G* parallel to *C D* ; and through *F* and *I*, the points of intersection of *C D* with the two parallels, draw *F K* and *I G* parallel to *A B*. This completes the hexagon, and also the plan of the prism. To draw the front elevation, measure off on the centre line *m n* the distance *a b* equal to 2″, and through the points *a* and *b* draw the horizontal lines *K G* and *L M*. Now, draw vertical lines through the points *K*, *E*, *I*, and *G* of the plan, and these vertical lines will intersect the horizontal lines *K G* and *L M* in the points *K*, *E*, *I*, *G*, and *L*, *N*, *P*, *M*, respectively. Draw the straight lines *K L*, *E N*, *I P*, and *G M*, and the front elevation is completed.

To draw the side elevation, extend the lines *G K* and *M L* to the left indefinitely, and between these two lines draw the vertical lines *I P* and *H Q* at a distance of $1\frac{1}{4}$″ from each

other. Midway between them draw the vertical line *G M*, and the side elevation is complete.

66. The views in Fig. **7** represent the **hexagonal pyramid,** illustrated in Fig. 75. Its base is a regular hexagon of the same size as the base of the prism in Fig. **6.** The plan, therefore, is a regular hexagon, and is constructed in the same way as in the case of the prism. This gives *A B C D E F*, Fig. **7.** From *O*, the intersection of the two centre lines, draw straight lines *O A*, *O B*, *O C*, *O D*, *O E*, and *O F*, the horizontal projections of the slanting edges of the pyramid.

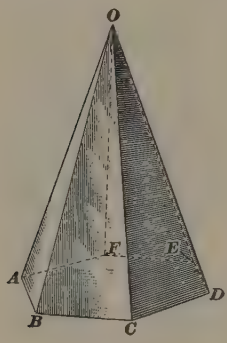


Fig. 75

To construct the front elevation, draw two indefinite vertical lines from *A* and *D* in the plan, and between them, above the plan, draw the horizontal line *A D*, intersecting the centre line at *a*. From *a*, lay off *a O* equal to 2″, and draw *O A* and *O D*. Next, by means of vertical lines, project the points *B* and *C* of the plan to *B* and *C* on *A D* in the front elevation, and draw *O B* and *O C*. This completes the front elevation. It will be observed that, in this view, three faces of the pyramid can be seen.

In the side view, or side elevation, only two faces are visible. To draw this elevation, extend *D A* of the front elevation to the left indefinitely, and on the line thus produced lay off *C E* equal to $1\frac{1}{4}$″. At its middle point *D*, erect a perpendicular *D O*, making it 2″ long. The elevation is then completed by drawing *O C* and *O E*.

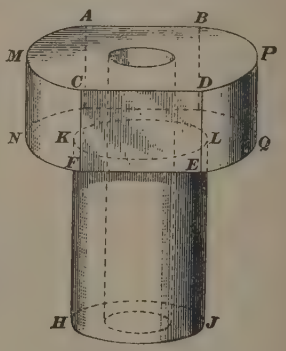


Fig. 76

67. In Fig. **8** are shown three views of the bush illustrated in Fig. 76. It consists of a cylindrical body 1″ in diameter with a collar $1\frac{3}{4}$″ in diameter and

$\frac{5}{8}''$ high, the latter being flat on opposite sides, forming two plane surfaces, one of which is shown at $C\ D\ E\ F$. The distance between these parallel faces is $1\frac{1}{2}''$. A hole $\frac{1}{2}''$ in diameter extends through the bush lengthways.

To make the drawing, begin with the plan. Draw the two centre lines $m\ n$ and $p\ q$, and with their point of intersection O as a centre draw three circles, making the outer one $1\frac{3}{4}''$ in diameter, the middle one $1''$ in diameter, and the inner one $\frac{1}{2}''$ in diameter. The middle one should be dotted. On $m\ n$ lay off $O\ a$ and $O\ b$ each equal to $1\frac{1}{2}'' \div 2 = \frac{3}{4}''$, and through a and b draw horizontal lines. These will intersect the outer circle at A, B, C, and D. The plan is then complete. The outer circle shows the collar; $A\ B$ and $C\ D$ are the projections of the parallel faces; the dotted circle is the projection of the body of the bush, which is hidden from an observer located above the bush; and the small inner circle is the projection of the hole through the bush.

To construct the front elevation, on the centre line $m\ n$ lay off $c\ d$ equal to $2''$ and then $d\ e$ equal to $\frac{5}{8}''$. Through the three points c, d, and e draw indefinite horizontal lines. Project the points f and g on the lines through d and e, locating the points M, N, P, and Q. Draw $M\ N$ and $P\ Q$. Project h and k in a similar fashion, as shown, thus locating $H\ K$ and $J\ L$. Next, project A and B, giving the lines $F\ C$ and $E\ D$. Finally, project the small circle of the plan, as indicated by the projection lines, giving the two dotted lines in the front elevation.

To draw the side elevation, produce the lines $P\ M$, $Q\ N$ and $J\ H$ of the front elevation horizontally to the left. Across them draw the vertical centre line $s\ t$, cutting the upper one at l and the lower one at m. Lay off $l\ D$ and $l\ B$ each equal to $1\frac{1}{2}'' \div 2 = \frac{3}{4}''$, and draw the vertical lines $D\ E$ and $B\ G$. Next, lay off $m\ R$ and $m\ S$ each equal to $1'' \div 2 = \frac{1}{2}''$, and draw the vertical lines $R\ U$ and $S\ T$. Finally, make $l\ r = l\ n = \frac{1}{4}''$, and draw the vertical dotted lines from r and n, as shown.

68. Fig. 9 shows a distance piece used to separate two other parts by a certain distance. The arrangement of the views of this figure is somewhat different from the preceding ones,

the side elevation being located at the right of the front elevation. Draw the centre line $m\,n$, and construct the figure according to the dimensions marked on the plate. Use a radius of $\frac{1}{8}''$ for the fillets, or curves, at A, B, C, and D, and an equal radius to round the corners at E, F, G, and H.

69. Fig. **10** shows a **cast-iron washer.** Instead of making an elevation and plan as usual, a section is taken through $p\,q$; that is, the washer is imagined to be cut on the line $p\,q$, with all that part of the figure to the right of $p\,q$ removed, and an elevation drawn of the remaining part. In order to distinguish a sectional drawing without any possibility of mistake, the so-called *section lines* are employed. These are usually drawn by laying a 45° set-square against the edge of the T square, and drawing a series of parallel lines as nearly equally spaced as can be judged by the eye. For cast iron, these lines are full, thin lines, all of the same thickness, and must not be drawn too near together. The styles of sectioning for other materials will be given later on. It is not usual to draw the section lines in pencil, but to wait until the outlines of the drawing have been inked in, and then section directly with the drawing pen. The shortest distance apart of the section lines should rarely be *less* than $\frac{1}{16}''$, unless the drawing is of such small dimensions as to cause a sectioning of this width to look coarse. This is the case with Figs. **10** and **11** of this plate. In these two figures make the section lines a full $\frac{1}{32}''$ apart. The only parts of the figure to be sectioned are those surfaces that are produced by cutting the ring along the line $p\,q$. The rest of the figure is drawn as if it were projected upon the vertical plane. The corners of this figure should be rounded with a radius of $\frac{1}{16}''$; the other dimensions can be obtained from the plate.

70. Fig. **11** is a **cylindrical cast-iron ring.** It is shown in plan and in section. The dimensions given suffice for the drawing of the figure without further explanations. The inner circle of the plan is the projection of the innermost points of the ring which form a circle whose diameter is $A\,B$.

71. When inking in a drawing, it is generally best to draw the circles and other curved lines first, and the straight lines

afterwards. This enables the draughtsman to easily blend into one line the straight lines meeting the curves, so that their points of meeting cannot be detected; it enables the tangent lines to be drawn with better success, and also shortens the time of inking in a drawing. It will be noticed that some of the straight lines are heavy and some light, and that parts of the full-line circles are heavy and the rest of the circle light. These are the shade lines; they are described later on. The student may make all of the full lines except the border lines of this plate, and the three following plates, of the same thickness, if he so desires. The dotted lines used to indicate those parts of the figures that are hidden must be of the same thickness as full lines, while the construction lines and centre lines should be very thin.

72. Dimensions.—The dimension lines and figures on this and succeeding plates are to be inked in by the student. Make the dimension figures $\frac{3}{32}''$ high, and of the same style as those shown in Art. **24**. Fractions should be $\frac{1}{8}''$ high over all. If there is not room for figures of this size, great care should be taken to make them *clear*.

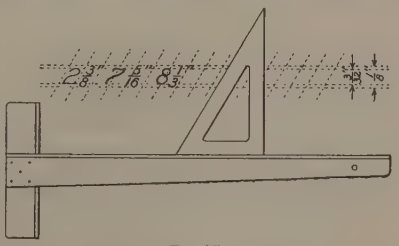


FIG. 77

Until after the student has obtained sufficient practice in lettering, he should draw guide lines in pencil for the dimension figures, as in Fig. 77, unless he can make them look well without. All the figures should have the same slant of 60°, and, when printing fractional dimensions, the *whole* fraction should have the same slant as the figures; that is, the denominator should be under the numerator in a *slanting* direction, and not straight below it. Make the dividing line between the numerator and the denominator horizontal, not slanting.

Dimension and extension lines must be light, broken lines of the same thickness as the centre and construction lines.

Care should be exercised to make the arrowheads as neatly as possible and of a uniform size. They are made with a Gillott's No. 303 pen, and their points must touch the extension lines, as illustrated in Fig. 78. Do not make arrowheads too pronounced.

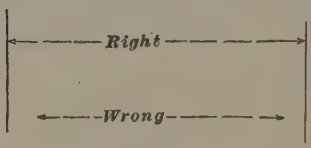


FIG. 78

When putting in the dimensions, care should be taken to give *all* that would be needed to make the piece which the drawing represents, but do not repeat the same dimension on different views. Thus, in Fig. **1** of this plate, the length is given in the front elevation as 2″, and it is obviously unnecessary to give the same dimension in the side elevation. Again, the dimension lines should be put where they would be most likely to be looked for. In Fig. **9** of this plate, the diameter of the central part of the distance piece is marked $1\frac{1}{4}''$ in the front elevation; it could have been marked on the side elevation, as the diameter of the dotted circle; but a person wishing to find the size of this part of the piece would naturally look for it in the front elevation. The diameter of the hole could be marked on the front elevation or on the side elevation, but it is put on the latter because it is denoted there by a full line, while in the front elevation the hole is dotted. Never cross one dimension line by another if it can well be avoided. Confusion and the possibility of errors will thus be minimized Thus, in Figs. **2** and **4** of this plate, the bounding lines of the triangular views are extended by fine broken lines, in order that the dimension lines ($\frac{3}{4}''$) may not cross the lines marking the length and width of the wedge.

All the figures used for dimensions shown on this and succeeding plates should be inked in on the drawing, but the letters used to describe the different objects should be omitted. Thus, in Fig. **1** of Plate I, the letters *A*, *B*, *C*, *D*, *E*, *F*, and *H* should not be inked in; but all the dimensions should be given clearly. The same rule applies to all succeeding figures. The titles should be made in block letters as shown on the sample copies. The date, name, and class letters and number are to be put on as in the preceding plates.

PROJEC

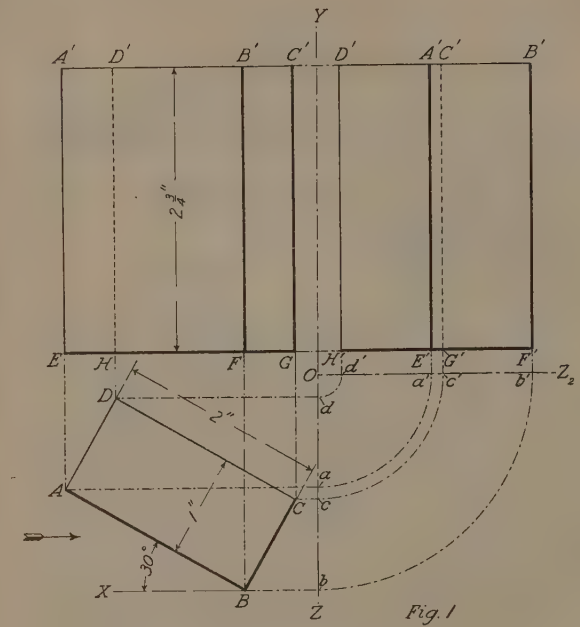
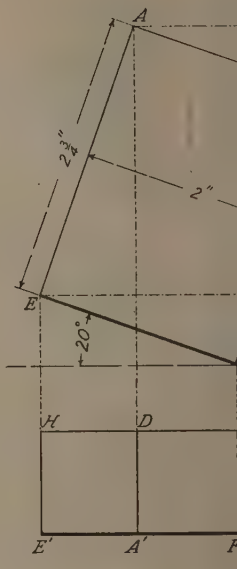


Fig. 1



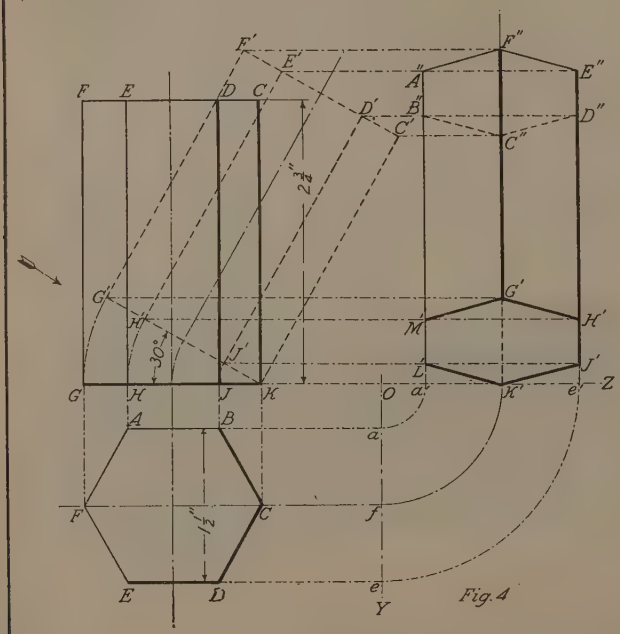
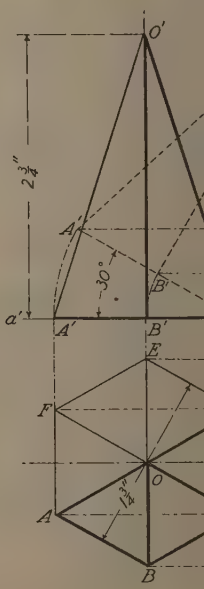


Fig. 4



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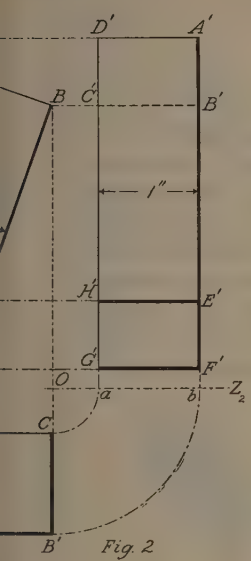

Fig. 2

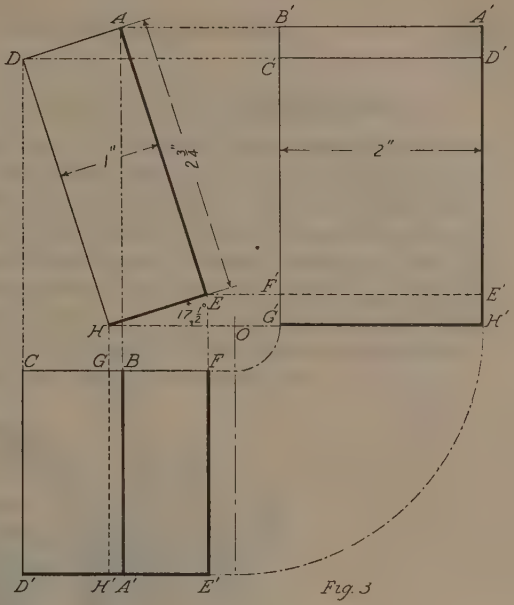

Fig. 3

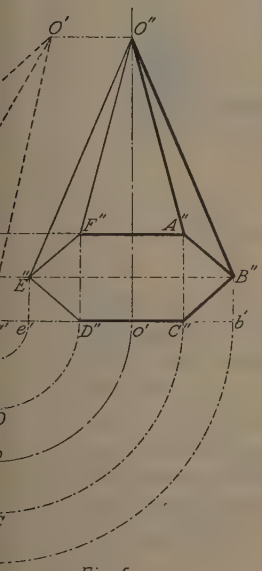

Fig. 5

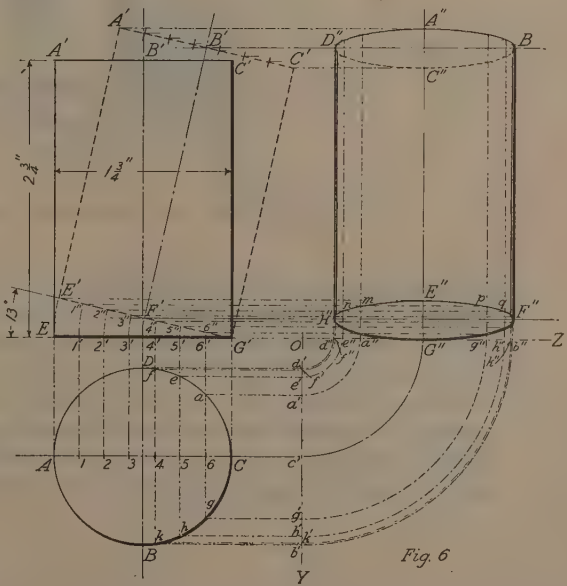

Fig. 6

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DRAWING PLATE, TITLE: PROJECTIONS II

73. The figures on the last plate were drawn under the supposition that the centre lines, and at least one flat side, were parallel to the plane of the paper; the centre lines were also either vertical or horizontal. This is always possible in detail drawings, where each piece is drawn separately, but in the case of machines, where the parts are placed at different angles, they cannot always be drawn in this manner. The figures on this plate are so drawn that they show objects similar to those in the last plate, but at different angles.

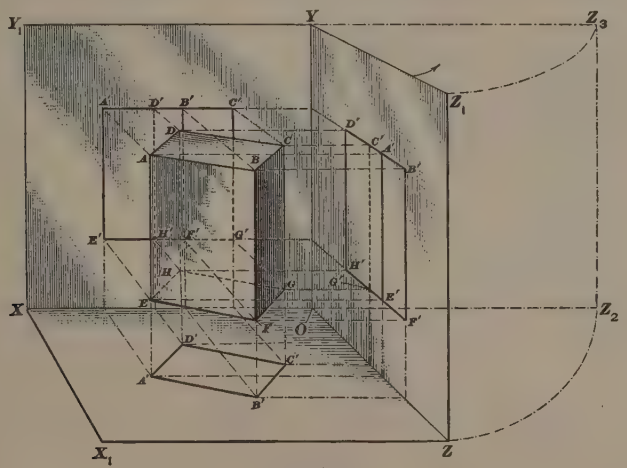

FIG. 79

74. On Plate II of Projections it will be observed that the arrangement of the three views is different from that in Plate I. The front elevation is above the plan, as before, but the side elevation is to the right, instead of to the left, of the front elevation. As has been stated previously, this alteration in relative positions is quite permissible, and does not change the accuracy or correctness of the drawing. It was made, in this case, because the several figures on the plate could then be arranged more symmetrically.

To indicate just how the three views come to occupy the relative positions shown, assume that a rectangular prism is placed in the angle formed by three planes at right angles to one another, as illustrated in Fig. 79. Further, assume that the upper and lower ends of the block, designated by *A B C D* and *E F G H*, respectively, are parallel to the horizontal plane *O X X*$_1$ *Z*, while the broad faces *A B F E* and *D C G H* are slanted backwards so as to make an angle of 30° with the vertical plane *O Y Y*$_1$ *X*, as shown.

If, now, the outline of the prism is projected upon the three planes, by the same methods as those used in Fig. 70, there will be

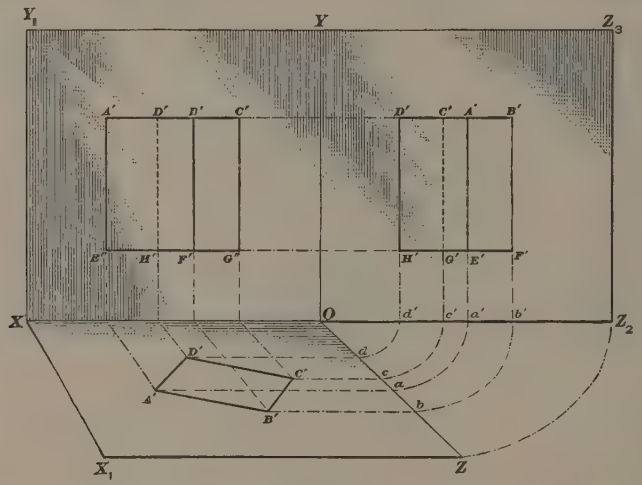

FIG. 80

produced three views of the block. Of these, the one on the plane *O Y Y*$_1$ *X* is the front elevation; that on the plane *O Z Z*$_1$ *Y* is the side elevation; and that on the plane *O X X*$_1$ *Z* is the plan. Now, if the plane *O Z Z*$_1$ *Y* is cut loose from the plane *O X X*$_1$ *Z* along the line *O Z* and is swung back, on *O Y* as an axis, in the direction of the arrow, it can be brought to the position *O Z*$_2$ *Z*$_3$ *Y*, thus being in the same plane with *O Y Y*$_1$ *X*.

75. When the plane *O Z Z*$_1$ *Y* has been thus swung back, the appearance of the three views will be as shown in Fig. 80.

The point Z moves in a circular arc, with O as a centre, to the position Z_2. Similarly, every other point in the plane $O\,Z\,Z_1\,Y$ describes an arc of a circle, $O\,Y$ being the axis in which the centres of these arcs all lie. Consequently, the points d, c, a, and b on the line $O\,Z$ will swing about O as a centre and will occupy the positions d', c', a', and b', respectively, on the line $O\,Z_2$.

If, next, the combined plane $Y_1\,Z_3\,Z_2\,X$ is swung backwards and downwards on $O\,X$ as an axis until it is horizontal and lies in the same plane with $O\,X\,X_1\,Z$, the three views will appear in the relative positions shown in Fig. **1** of Plate II of Projections.

76. In making the drawing of Fig. **1**, the plan is drawn first. Draw an indefinite line $X\,B$, and from B draw $B\,A$ 2″ long, making the angle $X\,B\,A$ equal to 30°. This is readily done by using the 60° set-square in connection with the **T** square. From A and B draw $A\,D$ and $B\,C$ at right angles to $A\,B$, making each 1″ long. Join D and C by a straight line. Then $A\,D\,C\,B$ is a rectangle 2″ by 1″, and represents the plan of the prism; that is, a view of the prism as seen from a point directly over it.

77. To construct the front elevation, first draw two parallel horizontal lines $A'\,C'$ and $E\,G$, $2\frac{3}{4}$″ apart, above the plan. From the points A, B, C, and D of the plan draw vertical projection lines, as shown. These will cut the horizontal line $A'\,C'$ at A', B', C', and D', and $E\,G$ at the points E, F, G, and H, respectively. Draw the straight lines $A'\,E$, $D'\,H$, $B'\,F$, and $C'\,G$. Then $A'\,D'\,B'\,C'\,G\,F\,H\,E$ will represent the prism as seen from the front, and will be the front elevation. Owing to the inclination of 30°, the observer will see one broad and one narrow side. These are represented in the front elevation by $A'\,B'\,F\,E$ and $B'\,C'\,G\,F$, respectively. The edge $D'\,H$ cannot be seen, as it is at the back of the prism, and therefore it is indicated by a dotted line.

78. To construct the side elevation, first continue the horizontal lines $A'\,C'$ and $E\,G$ of the front elevation indefinitely to the right. Slightly to the right of the line $C'\,G$ of the front elevation draw the vertical line $Y\,Z$, and somewhat below the line $E\,G$ draw the horizontal line $O\,Z_2$. Then, using the

T square, project the points A, B, C, and D of the plan on the line $Y\ Z$ by means of horizontal lines, as shown. The points a, b, c, and d are thus located. Now, with O as a centre, and $O\ d$, $O\ a$, $O\ c$, and $O\ b$ as radii, draw the arcs $d\ d'$, $a\ a'$, $c\ c'$, and $b\ b'$, respectively. From the points d', a', c', and b' thus determined, draw vertical lines cutting the produced horizontal lines. The lines $D'\ H'$, $A'\ E'$, $C'\ G'$, and $B'\ F'$ will thus be located. These lines represent the projections of the edges $D\ H$, $A\ E$, $C\ G$, and $B\ F$ of the prism as illustrated in Fig. 79. The edge $C\ G$ being hidden from the eye of the observer stationed at the left of the prism, its projection $C'\ G'$ in the side elevation is shown dotted. The other three vertical edges can be seen, and are therefore indicated by full lines.

79. In Fig. **2,** the prism is assumed to have its broad faces parallel to the plane $O\ X\ Y_1\ Y$ of Fig. 79, and its lower end tilted at an angle of 20° with the horizontal plane $O\ X\ X_1\ Z$. The front elevation is drawn first. It consists of a rectangle $A\ B\ F\ E$ whose length is $2\frac{3}{4}''$, and whose width is $2''$, and whose side $E\ F$ is inclined at an angle of 20° to the horizontal.

80. To construct the plan, draw vertical projection lines from the points E, A, F, and B downwards as shown. Across them draw a horizontal line cutting them in H, D, G, and C, and $1''$ below this a second horizontal line cutting them in E', A', F', and B'. Draw $H\ E'$, $D\ A'$, and $C\ B'$ in full lines and $G\ F'$ dotted, and the plan is completed. The edge whose projection is $G\ F'$ is the lowest edge of the prism and cannot be seen from above ; hence, $G\ F'$ is dotted in the plan.

81. In constructing the side elevation, select a point O in the vertical projection line $B\ B'$, lower than the point F, and draw the horizontal line $O\ Z_2$. Then O is the centre of the circular arcs used in drawing the side elevation. This differs slightly from the method in Fig. **1,** but it is quite as accurate, and more convenient. Draw arcs with $O\ C$ and $O\ B'$ as radii, thus locating a and b. From a and b draw vertical lines upward, and from A, B, E, and F of the front elevation draw horizontal projection lines cutting the verticals from a and b. The side elevation is thus determined. The edge $C'\ B'$ is shown dotted

because it is behind the prism and cannot be seen by the observer on the left.

82. In Fig. **3,** the narrow sides of the prism are assumed to be parallel to the plane $O\,Y\,Y_1\,X$, Fig. 79, and the base is inclined at an angle of $17\frac{1}{2}°$ to the horizontal plane. The front elevation is drawn first, consisting of a rectangle $2\frac{3}{4}''$ long and $1''$ wide, with its end $H\,E$ making an angle of $17\frac{1}{2}°$ with the horizontal. The plan is constructed by drawing two parallel horizontal lines $2''$ apart, below the elevation, and projecting the points D, A, H, and E on them, as shown. The point O, the centre of the circular arcs used in drawing the side elevation, is located on a horizontal line through H. This differs again from previous practice, but is convenient and quite correct.

83. Suppose that it is desired to obtain the front and the side elevation of a hexagonal prism having two of its parallel sides parallel to one of the vertical projection planes, and its base slanting at an angle of 30° to the horizontal plane. The method of drawing indicated in Fig. 4 may then be used.

First of all, draw the regular hexagon $A\,B\,C\,D\,E\,F$, making the distance between parallel sides equal to $1\frac{1}{2}''$. Then, above it, by means of the vertical projection lines shown, construct the front elevation of a hexagonal prism $2\frac{3}{4}''$ high. This elevation is shown in full lines, and represents the prism as standing squarely on its base, in a vertical position. It is desired, however, to obtain the front elevation showing the prism tilted so that its base makes an angle of 30° with the horizontal. The elevation under these conditions is indicated by the dotted outline. It shows the prism tilted over on the corner K until the line $K\,G$ of the base has swung up to the position $K\,G'$, making $G'\,K\,G = 30°$. To obtain this dotted outline, draw $K\,G'$ at an angle of 30° to $K\,G$, using the 60° set-square. With K as a centre, and $K\,G$, $K\,H$, and $K\,J$ as radii, draw the arcs $G\,G'$, $H\,H'$, and $J\,J'$, thus locating the points G', H', and J' on the line $K\,G'$. At each of the points G', H', J', and K erect a perpendicular to $K\,G'$, and across these perpendiculars draw the line $F'\,E'\,D'\,C'$ parallel to $G'\,K$ and at a distance of $2\frac{3}{4}''$ from it. The dotted outline thus produced is the required front elevation.

84. To obtain the side elevation, first draw a series of horizontal projection lines from the points C', D', E', F', G', H', J', and K, extending them to the right indefinitely. Select a point O on the line $K Z$, and draw the vertical line $O Y$. On $O Y$, by means of horizontal lines, project the points A, B, C, D, E, and F. Inasmuch as A and B are in the same horizontal line, their projection is the single point a; similarly, the projection of C and F is f, and of E and D is e. With O as a centre, describe arcs with $O\,a$, $O\,f$, and $O\,e$ as radii, locating the points a', K', and e' on $O Z$. At these three points erect perpendiculars to $O Z$, extending them upwards until they intersect the horizontal projection lines. Then, the intersection of the perpendicular from e' and the horizontal from E' is the corner E'' of the upper end of the prism in the side elevation. The intersection of the perpendicular from a' and the horizontal from E' locates the corner A''. The intersection of the perpendicular from K' and the horizontal from F' locates F''. In similar fashion, the remaining corners of both ends may be located. All the bounding lines of the base $M'\ G'\ H'\ J'\ K'\ L'$ are shown in full, as the entire surface of the base is visible to the eye of an observer stationed at the left of the prism when in its tilted position. The edges $B\,C$ and $C\,D$ of the top are not visible under these conditions, and consequently $B''\ C''$ and $C''\ D''$ are shown dotted. The side elevation thus produced is the side elevation of the prism when tilted as indicated by the dotted outline, and not an elevation of the outline shown in full lines. The hexagon $A\ B\ C\ D\ E\ F$ is a plan of the prism shown in full lines in the front elevation, but not of that shown in dotted lines, nor of that shown in the side elevation.

85. In Fig. 5 it is desired to show the front and side elevations of a hexagonal pyramid whose base is tilted on one of its edges until it makes an angle of 30° with the horizontal. To draw this, first construct a regular hexagon, as shown, making the distance between its parallel sides $1\frac{3}{4}''$. Above this, in the usual manner, construct the front elevation as it would appear with the pyramid standing squarely on its base. This is shown by the full lines. Now, as before, assume the base to be swung

upwards about the point C' as a pivot until it inclines at an angle of 30° to $a'\,C'$, and draw the front elevation of the pyramid, as shown by the dotted lines.

To construct the side elevation, draw a vertical and a horizontal line through the point C', as $C'\,b$ and $C'\,b'$. On $C'\,b$ project the corners A, B, C, D, E, and F of the hexagon. Then, by means of circular arcs and C' as a centre, locate the corresponding points on $C'\,b'$. At the points on $C'\,b'$ thus located, erect perpendiculars, and from the points O', A', B', and C' of the front elevation draw horizontal lines intersecting these perpendiculars. Then, as in the case of the prism in Fig. 4, determine the points A'', B'', C'', D'', E'', and F'', and join them by straight lines, thus forming the projection of the base. The point O'' is at the intersection of the horizontal from O' and the perpendicular from o'. Joining O'' with E'', F'', A'', and B'', the side elevation is completed.

86. In Fig. 6 is shown a cylinder $1\frac{3}{4}''$ in diameter and $2\frac{3}{4}''$ high inclined so that its base makes an angle of 13° with the horizontal. The circle $A\,B\,C\,D$, having a diameter of $1\frac{3}{4}''$, is drawn first, and above it the rectangle in full lines representing the front elevation of the cylinder when standing squarely on its base. Next, draw $G'\,E'$, making an angle of 13° with the horizontal, and on $G'\,E'$ construct the rectangle $A'\,C'\,G'\,E'$, $2\frac{3}{4}''$ by $1\frac{3}{4}''$, as shown by the dotted lines. This is then the desired front elevation.

To draw the side elevation, first divide the diameter $A\,C$ of the circle into a number of equal parts. At the points of division, as *1*, *2*, *3*, etc., erect perpendiculars, and continue them upwards until they intersect the horizontal through G' at the points *1'*, *2'*, *3'*, etc. Then, with G' as a centre, draw arcs through these points, and the arcs will intersect $G'\,E'$ at the points *1''*, *2''*, *3''*, etc.

Extend the horizontal line through G' to Z, and at some point O on this line draw a vertical line $O\,Y$ to the right of the circle. The vertical lines through *4*, *5*, and *6* intersect the circle at *a*, *e*, *f*, *g*, *h*, and *k*. From these latter points draw horizontal lines, projecting the points on the line $O\,Y$, as at

a', e', f', g', h', and k'. Also, project the points B and D to b' and d', and the points A and C to c'. Now, with O as a centre, strike arcs from the several points on $O\,Y$, and these arcs will cut $O\,Z$ at the points d'', f'', e'', a'', G'', etc. From these points draw vertical lines upwards, and from the points $1''$, $2''$, $3''$, etc., draw horizontal projection lines to the right, intersecting the vertical lines just drawn. The horizontal from E' intersects the vertical from G'' at E'', and E'' is one point on the projection of the base. The horizontal from $1''$ intersects the vertical from a'' at m, which is another point on the desired curve. Again, the horizontal from $2''$ intersects the vertical from e'' at n, and this becomes a third point on the curve. The horizontal from F' and the vertical from d'' intersect at H'' another point on the required projection. In the same manner, the remaining points p, q, F'', etc., are located. Through the intersections thus found, a smooth curve is drawn by use of the French curve, and the resulting figure, an ellipse, will be the projection of the base of the cylinder. The ellipse at the top is determined by exactly the same method as that used for the base. Having both outlines, the lines $D''\,H''$ and $B''\,F''$ are drawn, and the side elevation is completed.

DRAWING PLATE, TITLE: CONIC SECTIONS

87. When a cone or a cylinder is cut by a plane, the intersection of the convex surface and the plane is a curve that may have several different shapes, depending on the inclination or slant of the cutting plane. The various forms of figures that may be thus produced are known as **conic sections.**

If a cone is cut by a plane which is not at right angles to the axis and which does not intersect the base of the cone, the intersection forms an **ellipse.** A case of this kind is illustrated in Fig. **1.** It is evident that in order to conform to the above conditions the cutting plane must not be parallel to an element* nor to the axis.

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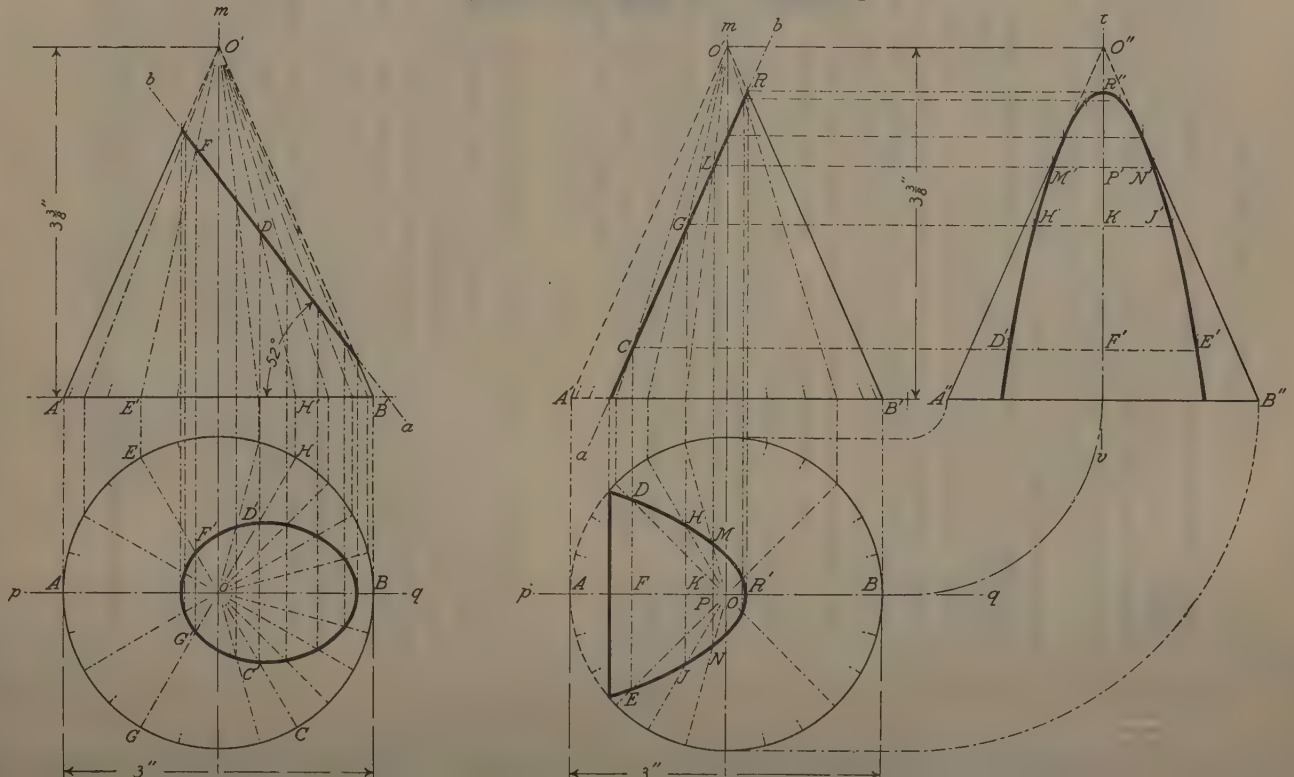
* Any straight line drawn on the surface of a cone and passing through the apex, as $O'\,A'$ or $O'\,H'$, Fig. **1,** is called an element.

CONIC SECTIONS.



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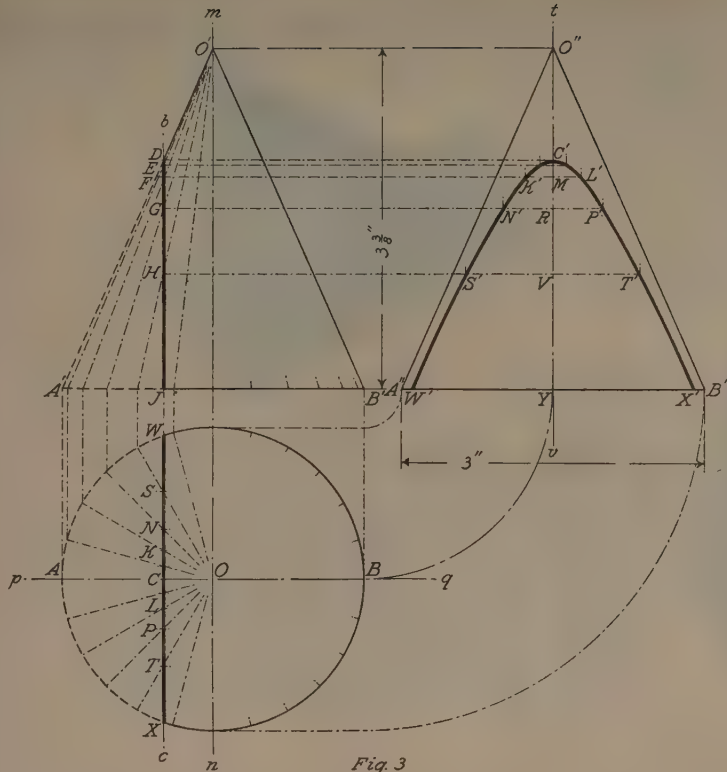

Fig. 3

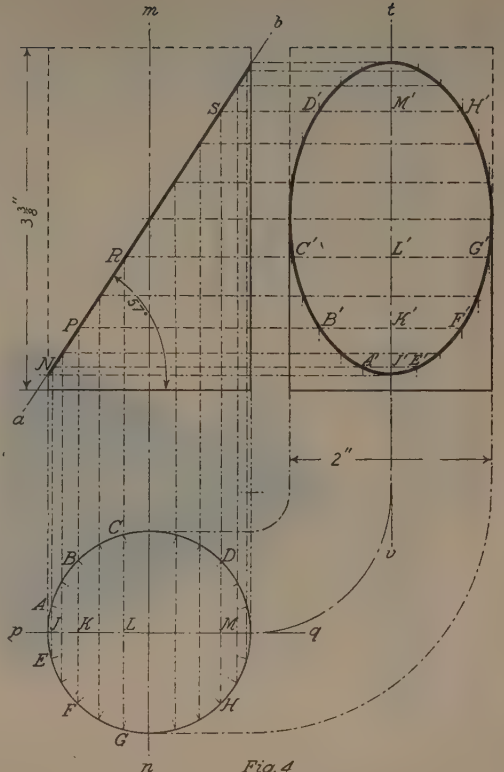

Fig. 4

In the specific case illustrated in Fig. **1**, the cutting plane is inclined so as to make an angle of 52° with the base of a right cone $3\frac{3}{8}''$ in height and 3″ in diameter at the base. The perspective view in Fig. 81 (*a*) shows the manner in which the plane *A B C D* cuts the cone *O E F*. If the portion of the cone above the cutting plane is removed, as in Fig. 81 (*b*), it will be seen that the outline of the section is an ellipse.

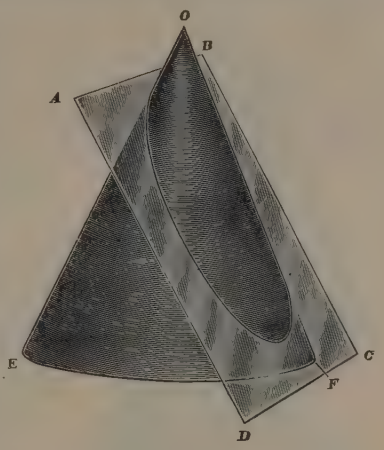

Fig. 81 (*a*)

To construct Fig. **1**, draw the plan and front elevation of a right cone $3\frac{3}{8}''$ high and 3″ in diameter at the base. Across the front elevation draw the line *a b*, representing the cutting plane, at an angle of 52° to the base.

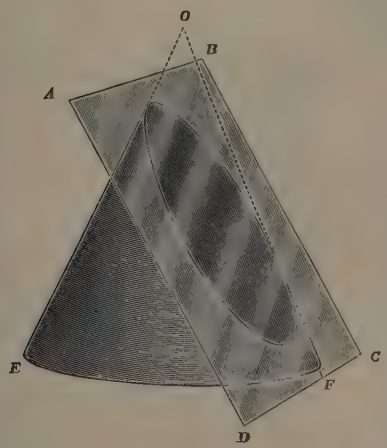

Fig. 81 (*b*)

Divide the circle which represents the plan into any number of parts, in this case 24, and, through the points of division *A*, *E*, *H*, etc., draw the radii *O A*, *O E*, *O H*, etc., to the centre *O*. Draw also from these points vertical projection lines cutting the base *A′ B′* of the front elevation in the points *E′*, *H′*, etc. From these latter points, draw lines to the apex *O′* of the cone, as *E′ O′*, *H′ O′*, etc., cutting the line *a b* in the

points F, D, etc. From the points F, D, etc., draw straight lines $F F' G'$, $D D' C'$, etc., parallel to the axis $m n$ of the cone, and intersecting the radii $O G$, $O E$, $O H$, $O C$, etc., in the points G', F', D', C', etc. Through these points of intersection draw the ellipse by aid of a French curve.

88. Fig. **2** shows a cone of the same size as in the preceding problem; but the cutting plane $a b$ is, in this case, parallel to one of the elements of the cone, and intersects the base. The curve formed by the intersection of a cone by a plane parallel to one of its elements, as illustrated in Fig. 82, is called a **parabola.** In Fig. **2** the plan and the front elevation of the cone and the curve of intersection in the plan are found by the same method as that used in the preceding problem. To find the side elevation, proceed as follows: Draw the side elevation $O'' A'' B''$ of the cone with the centre line $t v$ as its axis. Draw horizontal projection lines from C, G, L, etc., and from the points where they intersect $t v$ lay off $F' D'$ and $F' E'$ equal to $F D$ and $F E$ of the plan; $K' H'$ and $K' J'$ equal to $K H$ and $K J$ of the plan; $P' M'$ and $P' N'$ equal to $P M$ and $P N$ of the plan; and so on. Through the points D', H', M', N', J', E', etc., thus found, draw a smooth curve. The result will be the side elevation of the cone when cut by a plane parallel to one of its elements and having the upper part removed. The side elevation of Fig. **1** may be drawn in a similar manner.

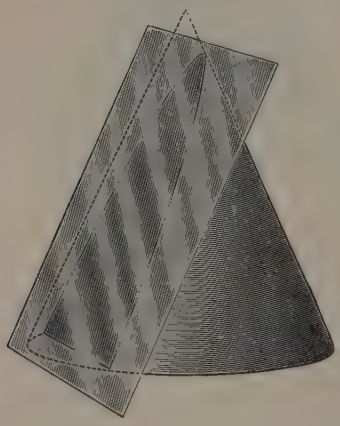

Fig. 82

89. Fig. **3** shows a cone having the same dimensions as in the two preceding problems, but cut by a plane $b c$ parallel to the axis of the cone. When the cutting plane intersects the base of a cone and is not parallel to any element (that is, if the

acute angle included between the cutting plane and the base is greater than the angle $O'A'B'$ included between any one element and the base), the curve of intersection is called a **hyperbola.** The method of cutting is shown in Fig. 83.

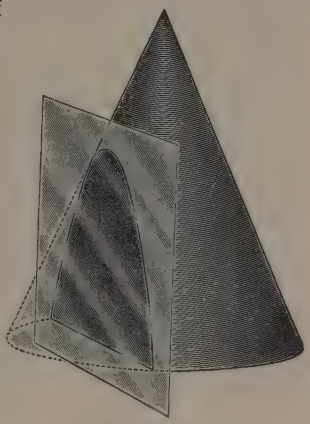

Fig. 83

The plan and front elevation are constructed as before. The projection of the curve in the plan in this particular case, where the cutting plane is parallel to the axis of the cone, is a straight line. The side elevation is found, as in the last problem, by drawing horizontal lines of projection from D, E, F, G, H, and J. From the points where they intersect $t\,v$, lay off MK' and ML' equal to CK and CL in the plan; RN' and RP' equal to CN and CP in the plan; VS' and VT' equal to CS and CT in the plan, and so on. The curve drawn through the points W', S', N', K', C', etc., thus found will be the required hyperbola.

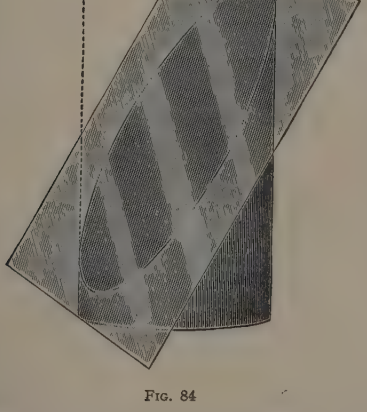

Fig. 84

90. Fig. 4 shows the intersection of a cylinder, $3\frac{3}{8}''$ long and $2''$ in diameter, by a plane $a\,b$ making an angle of 57° with the base. The manner in which the plane cuts the cylinder is shown in Fig. 84. The plan and front elevation, Fig. 4, may be drawn as already explained, the plan being a circle having

the same diameter as the base. To construct the curve in the side elevation, divide the circumference of the circle representing the plan into any number of equal parts, in this case 24, and through the points of division A, B, C, etc., draw vertical projection lines, as shown. These will cut $a\,b$ in the points N, P, R, etc., and when extended downward will cut the centre line $p\,q$ at J, K, L, etc., and the lower semicircle at E, F, G, etc. Now, from N, P, R, etc., draw horizontal projection lines until they intersect the centre line $t\,v$, as at J', K', L', etc. Then lay off $J'A'$, $J'E'$, $K'B'$, $K'F'$, etc., equal to JA, JE, KB, KF, etc., respectively, of the plan. A smooth curve drawn through the points A', B', C', D', etc., thus located will be the required projection of the intersection in the side elevation. The figure formed by the intersection of a cylinder and a plane inclined at an angle to the axis of the cylinder, as in the present case, is an ellipse.

DRAWING PLATE, TITLE : INTERSECTIONS AND DEVELOPMENTS

91. On this plate some dimensions are given in decimal fractions instead of vulgar fractions. Such decimal dimensions should be laid off with a decimal scale ; that is, a scale with inches divided into tenths, hundredths, etc. If the beginner has no decimal scale (and such a scale is not essential), he should take the nearest value of the decimal fraction in thirty-seconds of an inch.

To change a decimal to a vulgar fraction having a desired denominator, multiply the decimal by this number, and place the product over the same denominator. Thus, to express ·765″ in fourths, $\cdot 765 \times \frac{4}{4} = \frac{3\cdot 06}{4} = \frac{3}{4}''$ nearly ; to express ·765″ in thirty-seconds, $\cdot 765 \times \frac{32}{32} = \frac{24\cdot 48}{32} = \frac{24}{32}''$ nearly, etc.

The circumference of a circle is equal to the diameter multiplied by 3·1416. Thus, the circumference of a $1\frac{3}{8}''$ circle is $3\cdot 1416 \times 1\frac{3}{8}'' = 4\cdot 32'' = 4\frac{5}{16}''$; that of a $1\frac{1}{2}''$ circle is $4\cdot 71'' = 4\frac{23}{32}''$; that of a $1\frac{1}{4}''$ circle is $3\cdot 93'' = 3\frac{15}{16}''$; that of a $1\frac{9}{16}''$ circle is $4\cdot 9'' = 4\frac{29}{32}''$.

INTERSECTIONS A

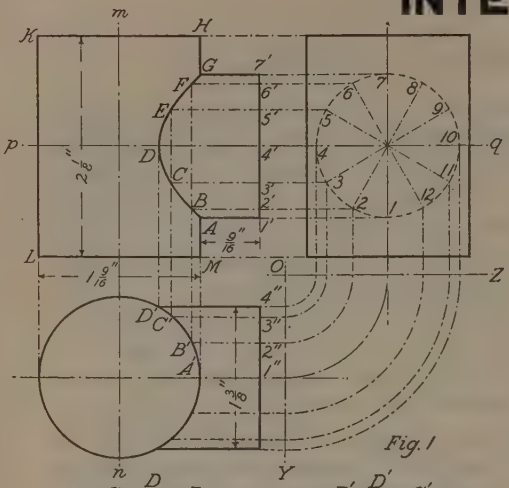

Fig. 1

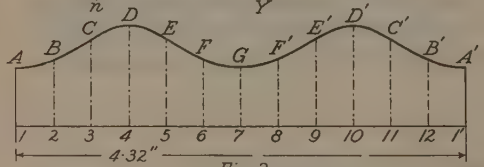

Fig. 2

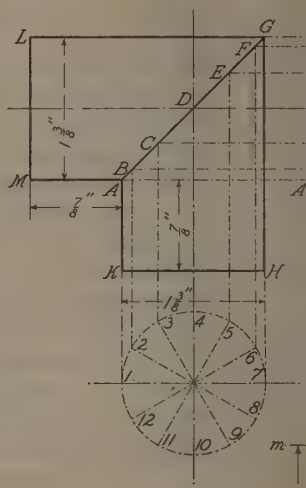

Fig. 3

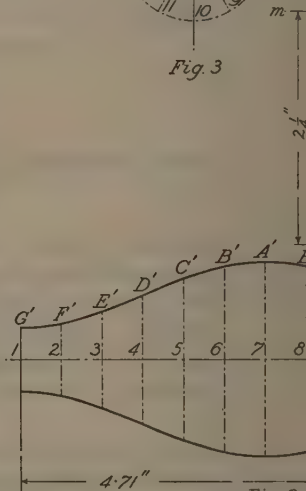

Fig. 9

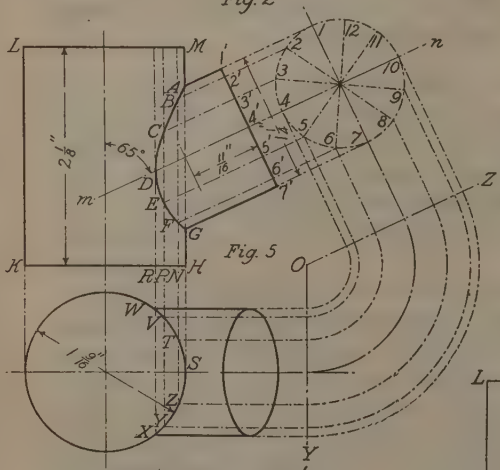

Fig. 5

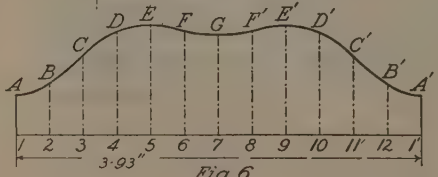

Fig. 6

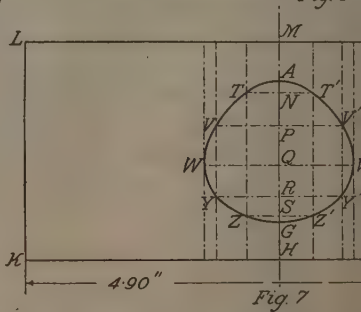

Fig. 7

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D DEVELOPMENTS.

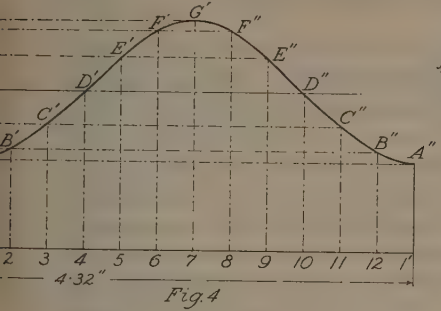


Fig. 4

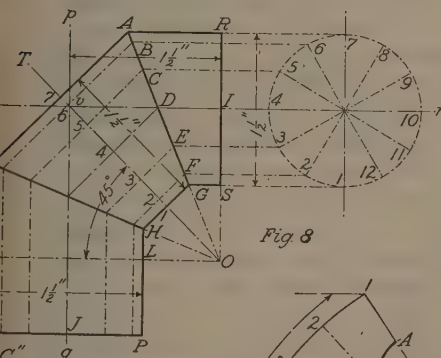
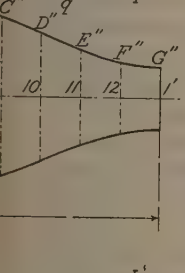
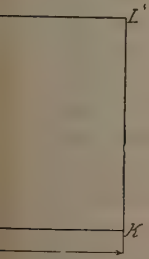


Fig. 8





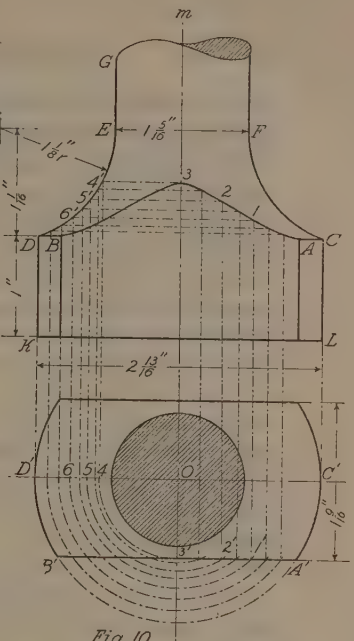


Fig. 10

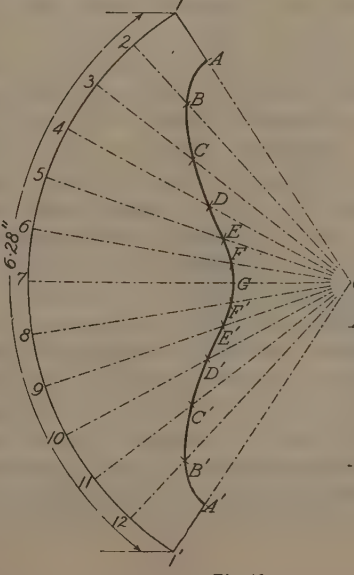


Fig. 12

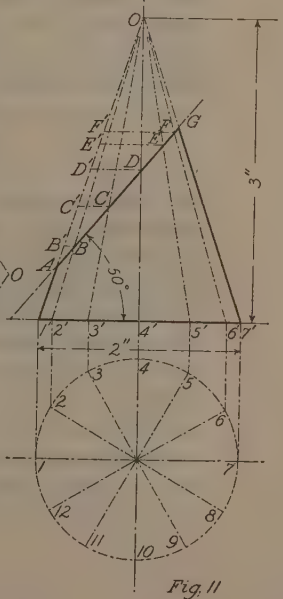


Fig. 11

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92. This plate deals with the intersection of surfaces and their development. Fig. **1** shows the intersection of two cylinders of different diameters whose axes *p q* and *m n* intersect at right angles. The dimensions are given in the figure. First draw the front elevation, consisting of the outline *7′ G H K L M A 1′*. The curve *A B C D E F G*, of course, cannot be drawn at this time, as its shape must be determined first. Below the front elevation draw the plan, and to the right of the front elevation the side elevation, as shown. Divide the circle in the side elevation into twelve equal parts, and by the method already explained project the points of division, *1, 2, 3, 4*, etc., to *1″, 2″, 3″, 4″*, etc., on the plan. From the points *1″, 2″, 3″, 4″*, etc., draw horizontal lines intersecting at *A′, B′, C′, D′*, etc., the circle representing the larger cylinder. Also, from *1, 2, 3, 4*, etc., draw horizontal lines intersecting *1′–7′* at *1′, 2′, 3′, 4′*, etc. Continue these lines to the left of *1′–7′*. Then lay off *2′ B* equal to *2″ B′*, *3′ C* equal to *3″ C′*, and *4′ D* equal to *4″ D′*, thus finding the points *B, C*, and *D*. The points from *A* to *D* on the curve are thus found. From *D* to *G* the points are found by the use of the same distances, but in reverse order. That is, lay off *5′ E* equal to *3″ C′*, and *6′ F* equal to *2″ B′*. Then, a smooth curve through *A, B, C, D, E, F*, and *G* is the required intersection of the two cylindrical surfaces, as seen in the front elevation. There is, of course, a similar curve from *G* to *A* on that part of the object hidden from view.

If the part *1′ A D G 7′* were assumed to be of thin sheet-iron, and if it were cut along the line *1′ A* and laid out on a flat surface, it would have the form shown in Fig. **2**, and this figure would be termed the **development** of the cylindrical part *1′ A D G 7′*. To determine the form and size of this development lay down a horizontal line *1–1′*, Fig. **2**, equal in length to 4·32″, the circumference of the circle shown in dotted lines in the side elevation, since this circle is the projection of the cylindrical part in question. Divide the distance *1–1′* into as many equal parts as were used in dividing the circle, in this case twelve, and at the several points of division erect perpendiculars to *1–1′*. Then, lay off *1 A*, *7 G*, and *1′ A′* each equal to *1′ A* in the front elevation; *2 B*, *6 F*, *8 F′*, and *12 B′* equal to *2′ B*

in the front elevation ; *3 C*, *5 E*, *9 E'* and *11 C'* equal to *3' C* ; and *4 D* and *10 D'* equal to *4' D*. A smooth curve through the points *A*, *B*, *C*, etc., thus found will complete the development. The form of this development is such that if it were cut out along its bounding line and bent into cylindrical form with the edges *1 A* and *1' A'* coinciding, its irregular edge would fit snugly to the larger cylinder, as indicated in the front elevation, Fig. **1.**

93. In Fig. **3** is shown the intersection of two cylindrical surfaces of the same diameter, meeting at right angles in such a manner that their axes also intersect. When the diameters are equal and the axes intersect, the front elevation of the curve of intersection of the two surfaces is always a straight line. This is true whether the axes are at right angles or not. Thus, in Fig. **3,** the projection of the intersection is the straight line *A G*.

To obtain the development of the cylindrical part *A G H K*, as shown in Fig. **4,** first draw below it the dotted circle representing its plan. Divide the circle into a number of equal parts, in this case twelve, and from the points of division draw vertical projection lines to meet *A G* at *A*, *B*, *C*, etc. Extend the line *K H* indefinitely to the right, and on the extended part lay off a distance *1 — 1'* equal to 4·32″, the circumference of the dotted circle. Divide this distance into twelve equal parts, also, and erect perpendiculars at the points of division. From *A*, *B*, *C*, etc., draw horizontal projection lines intersecting the perpendiculars in *A'* and *A″*, *B'* and *B″*, *C'* and *C″*, etc., and through the points *A'*, *B'*, *C'*, etc., thus found draw a smooth curve. The resulting figure is the required development. Since the part *A G L M* is exactly like *A G H K*, its development is the same as in Fig. **4.** Hence, if two flat, thin plates were cut to the same shape and size as this development and each was rolled into true cylindrical form with the edges *1 A'* and *1' A″* coinciding, they could be put together as shown in the front elevation and the slanting edges would be found to fit accurately at all points.

94. In Fig. **5** is shown the intersection of two cylinders of unequal diameters whose axes meet at an angle of 65° instead

of 90°, as in Fig. **1**. The method of finding the shape of the intersection is the same, in principle, as that used in connection with Fig. **1**. The only difference lies in the fact that *O Z* in Fig. **5** is drawn parallel to the axis *m n* of the smaller cylinder, and the points of division on the dotted circle are projected on *O Z* by perpendiculars to it, after which they are transferred to *O Y* by describing arcs in the manner already explained. The ellipse in the plan is the projection of the inclined end of the small cylinder in the front elevation, and its outline is determined by the method used in connection with Fig. 6 of Projections, Plate II.

95. The development of the smaller cylinder of Fig. **5** is shown in Fig. **6**. To draw it, lay off on a horizontal line the distance *1 — 1′* equal to 3·93″, the circumference of the dotted circle in Fig. **5**. Divide this distance into the same number of equal parts as was used in dividing the circle. At the several points of division erect perpendiculars, and, beginning at the left, lay off *1 A*, *2 B*, *3 C*, etc., equal, respectively, to the distances *1′ A*, *2′ B*, *3′ C*, etc., of Fig. **5**. Continue thus until the position *7 G* is reached. From *7 G* to *1′ A′* lay off the same distances as before, but in reverse order; that is, make *8 F′*, *9 E′*, etc., equal to *6′ F*, *5′ E*, etc., of Fig. **5**. Trace a smooth curve through the points thus located, and the resulting figure is the required development.

96. The development of the larger cylinder is shown in Fig. **7**. To obtain it, draw a rectangle *L K K′ L′* whose height *L K* is equal to the height *L K* of the cylinder, Fig. **5**, and whose length is equal to the circumference of the circle shown in full lines in the plan, Fig. **5**. At the middle point *H* of the line *K K′* erect the perpendicular *H M*, and from *H* lay off *H G*, *H S*, *H R*, *H Q*, *H P*, *H N*, and *H A* equal, respectively, to *H G*, *N F*, *P E*, *R D*, *P C*, *N B*, and *H A* in Fig. **5**. Through the points thus located on *H M*, Fig. **7**, draw horizontal lines. Then lay off *N T* and *N T′* each equal to the length of the arc *S T*, Fig. **5**; *P V* and *P V′* equal to the arc *S V*; *Q W* and *Q W′* equal to the arc *S W*; *R Y* and *R Y′* equal to the arc *S Y*; and *S Z* and *S Z′* equal to the arc *S Z*. Then, through

the points A, T, V, W, etc., thus located, draw a smooth curve, and the resulting outline will be the development of the intersection on the larger cylinder.

97. Fig. 8 shows a symmetrical **three-jointed elbow** formed by the intersection of three cylindrical surfaces. The diameter of each of the three surfaces is $1\frac{1}{2}''$. The centre lines of the surfaces $R\ A\ G\ S$ and $M\ N\ P\ H$ are to be at right angles to each other; then, in order that the arrangement shall be symmetrical, the centre line of the third surface $A\ M\ H\ G$ must make an angle of 45° with the centre lines of the other two.

To construct the elevation as shown in the figure, draw the two centre lines $m\ n$ and $p\ q$ at right angles to each other; they intersect at v. Lay off $v\ I = 1\frac{1}{2}''$ and draw an indefinite line $R\ S$ through I perpendicular to $m\ n$. Make $I\ R$ equal to $I\ S = 1\frac{1}{2} \div 2 = \frac{3}{4}''$, and draw $R\ A$ and $S\ G$ parallel to $m\ n$. Draw $O\ K$ parallel to $m\ n$ and $1\frac{1}{2}''$ below it. Through the point O, where $R\ S$ and $O\ K$ intersect, draw $O\ T$ passing through v, and bisect the angle $R\ O\ T$ by the line $O\ A$, which intersects $R\ A$ and $S\ G$ in A and G. Lay off $v\ J = 2\frac{1}{4}''$ and draw $P\ J\ N$ perpendicular to $p\ q$. Make $J\ P = J\ N = 1\frac{1}{2} \div 2 = \frac{3}{4}''$, and draw $P\ H$ and $N\ M$ parallel to $p\ q$. Draw $O\ M$ so as to bisect the angle $T\ O\ K$; $O\ M$ intersects $P\ H$ and $N\ M$ in H and M. Finally, draw $A\ M$ and $G\ H$.

98. In Fig. 9 is shown the development of the middle section $A\ G\ H\ M$ of Fig. 8. First lay down 1–$1'$ equal in length to $4{\cdot}71''$, the circumference of a circle $1\frac{1}{2}''$ in diameter. Divide this into twelve equal parts corresponding to the twelve equal parts into which the dotted circle in Fig. 8 is divided. Project the points of division on this circle to $O\ A$, thus locating the points B, C, D, etc., and from these latter points draw lines across the section $A\ G\ H\ M$ perpendicular to $O\ T$, and cutting $O\ T$ in 6, 5, 4, etc. Then, in Fig. 9, make $1\ G'$ and $1'\ G''$ equal to $1\ G$, Fig. 8; $2\ F'$ and $12\ F''$ equal to $2\ F$; $3\ E'$ and $11\ E''$ equal to $3\ E$; $4\ D'$ and $10\ D''$ equal to $4\ D$; $5\ C'$ and $9\ C''$ equal to $5\ C$; $6\ B'$ and $8\ B''$ equal to $6\ B$; and $7\ A'$ equal to $7\ A$. A curve through the points G', F', E', D', etc., gives the outline of the upper half of the development. The other half

is precisely like it, and is obtained by laying off below *1–1′* the same distances as were laid off above it.

99. In Fig. **10** is illustrated a solid originally a cylinder $2\frac{13}{16}''$ in diameter, but afterwards turned down at one end to $1\frac{5}{16}''$ diameter, and the other end flattened so that the parallel flat faces are $1\frac{9}{16}''$ apart. It is desired to find the exact form of the curve *A 1–2–3 B* representing the intersection of the flat surface and the curved surface.

First, draw the plan and front elevation, using the dimensions given, but omitting the curve *A 1–2–3 B*, of course, as that is to be determined. To draw the arc *D E*, locate its centre *H* at a distance of $1'' + 1\frac{1}{16}'' = 2\frac{1}{16}''$ above *K L* and $1\frac{1}{8}''$ to the left of *E G*. Then, with a radius of $1\frac{1}{8}''$, describe the arc *D E*. The arc *C F*, on the opposite side, has the same radius and its centre is located in the same manner as the centre *H*, but on the right of *F*.

Now, with *O* as a centre and radii of suitable lengths, describe arcs cutting *B′ A′* in several points, as *1′*, *2′*, etc., between *A′* and *3′*. Continue these arcs until they intersect the horizontal line *D′ C′*, thus giving the points *4*, *5*, *6*, etc. By vertical projection lines, project the points *4*, *5*, *6*, etc., upwards on the arc *D E*, locating the points *4′*, *5′*, *6′*, etc. From these latter points draw horizontal lines, as shown, and from the points *1′*, *2′*, *3′*, etc., in the plan draw vertical lines until they intersect the horizontal lines. The point *1*, where the horizontal through *6′* intersects the vertical through *1′*, is one point on the desired curve. The point *2*, where the horizontal through *5′* intersects the vertical through *2′*, is another point on the curve. The point *3*, on the centre line, where the horizontal through *4′* cuts the vertical through *3′*, is the middle point of the curve. Other points between *3* and *A* may be found in the same way. Then, a smooth curve through *A*, *1*, *2*, and *3* will be one-half of the required curve. The other half is exactly like the one just drawn, and may be obtained by laying off distances to the left of *m n* equal to the distances of *1*, *2*, etc., from *m n*.

100. Fig. **11** shows a conical surface cut by a plane, and Fig. **12** shows its development. Draw the elevation and horizontal projection of the base as shown in Fig. **11**. Divide

the dotted circle into a convenient number of equal parts, in this case 12, and project the points *1*, *2*, *3*, etc., on the base *1′–7′*, thus locating the points *1′*, *2′*, *3′*, etc. Join these points with the apex *O* of the cone, by the lines *O 1′*, *O 2′*, *O 3′*, etc., cutting the plane in *A*, *B*, *C*, etc. Now, choose a convenient point *O*, Fig. **12**, and with this as a centre, and a radius equal to *O 1′*, or *O 7′*, Fig. **11**, the slant height of the cone, describe an arc *1–1′*. Make the *length of this arc* equal to the length of the circumference of a circle having the same diameter as the base of the cone. This may be conveniently done as follows: the length of the arc $= 2 \times 3{\cdot}1416 = 6{\cdot}28''$, nearly. Draw a straight line $6{\cdot}28''$ long and divide it into, say, 4 equal parts. Describe an arc having a radius equal to *O 1′*, the slant height of the cone, and find the length of a part of this arc equal to $6{\cdot}28 \div 4 = 1{\cdot}57''$ by means of the method described in connection with Fig. 53. With the dividers set for the chord of the arc just found, space off the chord four times on the longer arc *1 2 3 . . . . 1′*, Fig. **12**, thus determining the points *1* and *1′* on this arc. Now, divide the arc *1-1′* into the same number of equal parts that the circle *1 2 3 . . . . 12* has been divided into, that is, 12 parts. Join the points of division *1*, *2*, *3*, etc., with the centre *O* by the lines *O 1*, *O 2*, *O 3*, etc., as shown. Project the points *B*, *C*, *D*, etc., Fig. **11**, upon *O 1′*, in *B′*, *C′*, *D′*, etc., as shown, and lay off *O A* and *O A′*, Fig. **12**, equal to *O A*, Fig. **11**; *O B* and *O B′*, Fig. **12**, equal to *O B′*, Fig. **11**; *O C* and *O C′*, Fig. **12**, equal to *O C′*, Fig. **11**, etc., and through these points draw a curve, which will be the desired development of the intersection. A plate cut of the same size and shape as shown by *A G A′ 1′ 7 1* can be bent into the conical surface shown by the elevation *A G 7′ 1′*.

Particular attention must be given to the method explained above for laying out the curve of the development in Fig. **12.** It would be entirely wrong to take the measurements from the lines *O F*, *O E*, *O D*, *O C*, etc., Fig. **11**. The reason for this is that these lines, being on the surface of the cone, are inclined toward the observer, and so do not appear in their true lengths. The line *O D*, for example, if measured on the surface of the cone itself, would evidently be of the same length as the line *O D′*;

but in the figure it is much shorter. The line $O\,D'$, however, appears in its true length in the figure, because it is not inclined to the observer in the position shown. The actual distance of point D from the apex O, therefore, is $O\,D'$, which is the distance to be laid off for point D in the development. The same holds true for the other points.

SHADE LINES

101. The use of the heavy shade line will now be explained. In Fig. 85, by means of the shade lines, the draughtsman knows, without looking at any other view of the object, that the rectangles *1* and *4* represent square holes, and *2* and *3*, square bosses. When he looks at the other view, it is to find the depth of the holes and the height of the bosses. This explains the use of the shade lines, viz.: to show, from that view of the drawing which is being examined, whether the part looked at is in front or behind the plane of the surface; that is, for example, whether the rectangles *1*, *2*, *3*, and *4* are the fronts of bosses or bottoms of holes, and, consequently, whether they extend beyond or behind the surface of *A B D C*. In order that the shading may be uniform on all drawings, the light is assumed to come in one invariable direction in such a manner as to be parallel to the plane of the paper, to make an angle of 45° with all horizontal and vertical lines of the drawing, and to come from the upper left-hand corner of the drawing. Each view of the object represented is shaded independently of any of the others; and, when shading, the object is always supposed to stand in such a position that the drawing will represent a front view. Any surface that can be touched

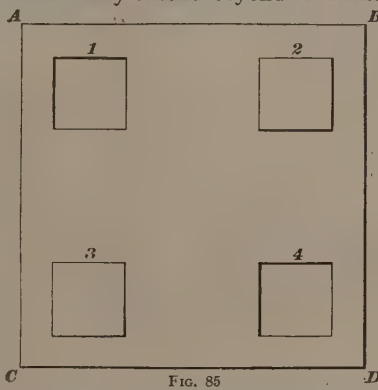

FIG. 85

by drawing a series of parallel straight lines, making an angle of 45° with the horizontal and vertical lines of the drawing, is called a **light surface**; a surface that cannot be touched by lines having this angle is called a **dark surface.** All of the edges caused by the intersection of a light and dark surface, or two dark surfaces, are usually shaded; that is, the edges thus formed are drawn in heavy lines. Exceptions to this rule are sometimes made by experienced draughtsmen, when a rigid adherence to it will produce a bad effect or will render the drawing ambiguous.

102. Fig. 86 is an elevation of a series of triangular wedges radiating from the common centre *O*. The front is, of course, a light surface, and, in order to determine whether the side surfaces are light or not, the 45° set-square may be used. Take the wedge *R O A*. A line drawn at an angle of 45°, the direction of the arrows, would strike the side of which *O A* is the edge; hence, this side is a light surface, and the front being also a light surface, the line *OA* must be light. On the contrary the light cannot strike the side of which *OR* is the edge without passing through the wedge. Hence, this is a dark surface, and its intersection *O R* with the light surface *O A R* requires a shaded line. For the same reason, *A R* is also shaded. The same reasoning as the above applies to the lines *O B*, *O D*, *O G*, *O I*, *O K*, and *O M*; also, to *Q N*, *M L*, and *K J*. *C B* is not shaded, because the light strikes the surface of which *C B* is the edge, as shown by the arrow, making *C B* the intersection of two light surfaces. *O N* makes an angle of exactly 45° with the horizontal, and

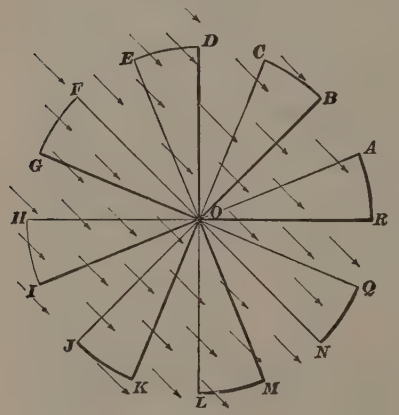

FIG. 86

is treated as if it were the edge of a light surface; this is done in every case in which the line considered makes an angle of 45° with the horizontal.

103. In shading holes, or any parts of the drawing denoting depressions below the surface under consideration, a slightly different assumption is made. Fig. 87 is an elevation of a square block with a hexagonal hole in the centre. If the light passed over the surface *A B C D*, parallel to the plane of the paper as previously assumed, all the inside surfaces would be dark, and the entire outline of the hexagon *E F G H I K* would be shaded. In order to prevent this and make the work similar to that which has preceded, the rays of light are assumed to make an angle of 45° with the plane of the paper when shading holes and depressions. Hence, the light will strike the surfaces whose edges are *G H*, *H I*, and *I K*, as shown by the arrows, leaving the surfaces whose edges are *K E*, *E F*, and *F G* dark as before. Therefore, these latter edges will be shaded, and the edges *G H*, *H I*, and *I K* will be light. See also Fig. 85.

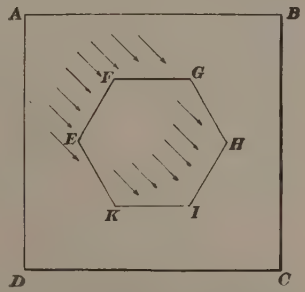

FIG. 87

104. The conventional method of shading circles which represent the projections of cylinders, or circular holes, is as follows: *A B*, Fig. 88, is the end elevation of the circular base *A B* of a cylinder. Draw the arrows *E A* and *F B*, making angles of 45° with the horizontal diameter and tangent to the circle at *A* and *B*. That half of the circle below these two points of tangency is to be shaded, and, in order to make the drawing look well, the centre point for the compasses is shifted along the line *C H* parallel to *E A* and *F B* and in the same direction an amount equal to the thickness of the desired line. With the same radius that was used to describe the original circle, describe part of another circle, being careful not to run over the first circle, and stopping when the two lines

coincide. The directions for shading a hole are precisely the same as for the projection of a cylinder base, except that the half *B C A* of the circle in Fig. 89 is to be shaded, the centre being shifted as before, and in the same direction, as shown by the arrow.

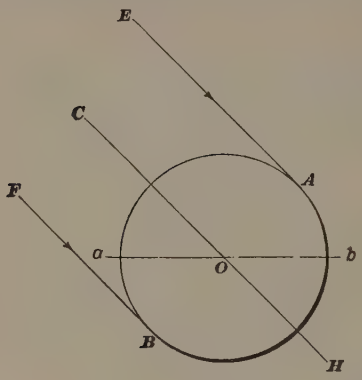

Fig. 88

Vertical projections of cylinders are shaded as shown in the front elevation of Fig. 5, Drawing Plate, title: Projections I.

After studying the foregoing concerning shade lines, the student should be able to see the reason for the using or omitting of any shade lines on the drawings in the accompanying plates. In the case of an object like the hexagonal prism in Fig. 6, Drawing Plate, title: Projections I, no part of the upper base or line *K G* is shaded, although, strictly speaking, the part *I G* of the line should be shaded; but, as this would make part of the straight line *K G* heavy and the greater part light, the whole line is drawn light. This is one of the exceptions previously mentioned.

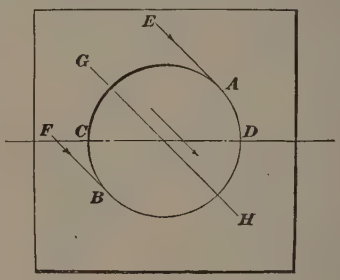

Fig. 89

ARCHITECTURAL DRAWING

INTRODUCTION

CLASSIFICATION OF DRAWINGS

1. **Architectural Drawing** includes both instrumental drawing of the kind described in *Geometrical Drawing* and freehand drawing. The latter is of the class known as ornamental drawing. In architectural drawing the larger part consists of straight- and curved-line work executed entirely with instruments. The ornamental drawing is largely made up of curved-line work done freehand, although occasionally a French curve may be found useful. In the plates belonging to this Section only a limited amount of ornamental drawing will be required, and it is of a character that should not cause any difficulty in executing.

2. While the drawings made in the various architects' offices may vary in many important details, it should be noted that good drawings made in one office can be read in others. In general, all architectural drawings are made as plain as possible, shading and other aids for making the drawing clearer being omitted except in cases where it is necessary to bring out important details of the design. It is not good practice to spend time on elaborate titles, as plain letters serve all purposes and do not waste the time of the draughtsman.

The methods here described are those which have been found to be the most representative and complete. They can easily be adapted to the methods used in any particular office, if they should differ in any particular with the practice here described.

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3. The architectural drawings used in practice may be classified as follows: (1) *Sketches*, and (2) *Working Drawings*.

The **sketch** consists of a series of drawings furnished the client by the architect, in which the latter generally shows a perspective view of the structure to be erected. In the case of a residence, it is accompanied by plans of the various floors so as to indicate the general arrangement of the rooms. As this sketch is more or less tentative, it is not accurately made as to dimensions and details. It is intended merely to give a general idea of the structure and may have to be altered several times before it is finally accepted by the client.

4. If the design represented by the sketch is satisfactory, the architect is requested to prepare **working drawings,** which are drawings of the structure made to scale containing all the data required for its erection. These drawings give exterior views of the structure as it will appear when viewed from different positions. They show, also, plans of the several floors and of the roof, also sections showing the construction and positions of stairs, floors, etc.

5. Working drawings may be further classified as *plans*, *elevations*, *sections*, *detail drawings*, and *full-size details*.

Plans include drawings that give plan views of the foundations, the different floors, and the roof.

Elevations are exterior views of the building as it will appear when viewed from the front, the sides, or the rear.

If it is required to show the arrangement of interior staircases, landings, etc., the building is supposed to be cut by an imaginary vertical plane at a convenient place, and it is further supposed that the part situated at one side of the cutting plane between it and the observer is removed. A drawing representing the plane of intersection of the remaining part of the structure is called a **section.**

Drawings are made of entrances, doors, fireplaces, etc., on a larger scale than the plans and elevations. Such drawings are called **detail drawings.**

Details of windows, doors, etc., are usually shown full size, and such drawings are therefore termed **full-size details.**

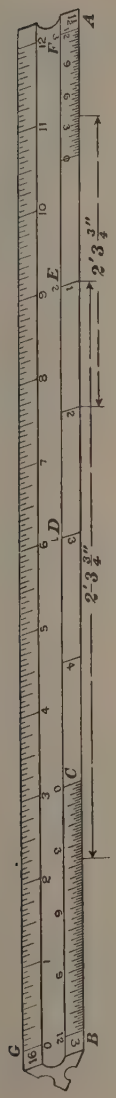


FIG. 1

SCALES

6. It is seldom convenient to make the drawing of an object full, or life, size, it being more often necessary to show it as reduced in size. Thus, supposing it is desired to make a drawing $\frac{1}{4}$ full size, then 12″ on the object will be represented by 3″ on the drawing; hence, if 3″ is set off and divided into 12 equal parts, each of these parts will represent 1″ on the object. If these parts are subdivided into 2, 4, or 8 parts, each will represent $\frac{1}{2}$″, $\frac{1}{4}$″, or $\frac{1}{8}$″ on the object. A scale of this kind is called a **$\frac{1}{4}$ full size,** or a **scale of 3″ to the foot.** A **$\frac{1}{8}$ full size,** or a **scale of $1\frac{1}{2}$″ to the foot,** is constructed in the same way, except that $1\frac{1}{2}$″ would be set off instead of 3″.

7. Fig. 1 shows a scale which is convenient in form, inasmuch as it combines eleven systems of subdivision and may be used for all the work ordinarily done in a drawing office. This scale is triangular in section and 12 inches in length, and on each of its edges there is set off a scale, as shown at *A*, *B*, and *G*. The scale at *G* is "full size"; that is, this edge of the scale is divided into inches and fractions of an inch down to sixteenths, and is used for drawings in which an object is represented in its natural size. On its opposite side, at *B*, is shown the quarter full-size scale of 3″ = 1 ft., on drawings generally written *3 in. to 1 ft.* The first 3-inch (actual size) division, from *B* to *C*, is subdivided into 12 parts representing inches, and each inch is then divided into proportional fractions of an inch, generally eighths. From *C* to *D*, *D* to *E*, and *E* to *F* the scale is marked in its main divisions of 1 foot each, each foot being 3″ long,

actual size. From *A* to *B* the scale is independently divided into spaces of $1\frac{1}{2}''$ (actual size) to form an eighth-size scale, or $1\frac{1}{2}'' = 1$ ft., the divisions of the latter occurring on and between the marks for the $3'' = 1$ ft. scale.

The other sides and edges of the instrument are divided into scales of $1''$ and $\frac{1}{2}''$, $\frac{3}{4}''$ and $\frac{3}{8}''$, $\frac{1}{4}''$ and $\frac{1}{8}''$, and $\frac{3}{16}''$ and $\frac{3}{32}''$ to the foot. Different makers do not always arrange their scales in the same manner. Thus, instead of having a full-size scale and scales of $3'' = 1$ ft. and $1\frac{1}{2}'' = 1$ ft. on one side, as shown in Fig. 1, some makers have the full-size scale and $\frac{3}{16}'' = 1$ ft. and $\frac{3}{32}'' = 1$ ft. on one side. It will be observed that the numbering of feet on these scales does not start at the end of the instrument, but at the first main division from the end. Thus, on the quarter full-size scale the zero mark is placed at *C* and the first foot is measured to *D*. This is done so that the feet and inches may be set off independently and with one reading of the scale.

The figures indicating the number of feet on this scale are placed along the inside edge at *D*, *E*, and *F*, the numbers running in a direction away from the part containing the inches. The numbers indicating inches run in an opposite direction to those defining the feet.

8. To set off $2'\ 3\frac{3}{4}''$ on a scale of $3'' = 1$ ft., and from a given point, place the scale on the point so that the 2-foot mark will be directly over it; then, from the zero mark *C*, set off $3\frac{3}{4}''$, as shown, fixing a second point. The length of the distance thus set off between the two points represents $2'\ 3\frac{3}{4}''$. The scale of $1\frac{1}{2}'' = 1$ ft. is used in a similar manner to set off the same distance. The figures indicating feet on this scale are placed nearer the edge, in order to prevent confusion in reading.

To draw to half-size, or to a scale of $6'' = 1$ ft., use the full-size scale, and remember that every $\frac{1}{2}''$ on that scale corresponds to $1''$ on the object; that is, that every dimension is only one-half of the real length. To set off $5\frac{7}{8}''$, set off 5 half-inches and $\frac{7}{16}''$ over; the result is a line $5\frac{7}{8}''$ long to a scale of $6'' = 1$ ft.

In all kinds of architectural drawing, the smaller scales are used more frequently than the larger ones, and it is customary

to speak of them as $\frac{1}{4}$ scale, $\frac{1}{8}$ scale, etc., in which case scales of $\frac{1}{4}''$ or $\frac{1}{8}''$ to the foot are meant. These expressions must not be confused with the $\frac{1}{4}$ full size and $\frac{1}{8}$ full size, which refer to scales of 3″ and $1\frac{1}{2}''$ to the foot, respectively.

9. Plans for buildings are usually drawn at $\frac{1}{8}''$ to the foot, and preliminary sketches on a scale of $\frac{1}{8}''$ or $\frac{1}{16}''$ to the foot; that is, each $\frac{1}{8}$ or $\frac{1}{16}$ inch on the drawing represents 1 foot in the finished building. Besides the scale, shown in Fig. 1, a variety of other forms of scales are used in architectural drawing offices. Some of these scales are thin and flat, others have rounded surfaces so that either of the edges may be tipped down into contact with the drawing. These scales contain in general only divisions corresponding to $\frac{1}{8}''$, $\frac{1}{4}''$, and $\frac{1}{2}''$ to the foot. The method of using them is the same as that explained with reference to Fig. 1.

DRAWING-OFFICE STAFF

10. In an architectural drawing office the architect has a number of assistants, who may be classified according to their rank and experience, as follows:

1. *Chief Assistants.*—In large offices where contracts are undertaken for a number of extensive buildings, each building is often placed in the hands of a chief assistant, who is entirely responsible to the architect for the carrying out of the whole work connected with this particular building. He will superintend its erection and prepare all the drawings and details, and also settle all points raised by the contractor, referring to the architect himself only on important points. In offices where the work in hand is less extensive, there will be only one chief assistant, who will be responsible for the general work in the office.

2. *Assistants.*—The chief assistant will have one or more assistants who will execute certain work under his supervision, such as completing plans and making detail drawings from plans or elevations.

3. *Junior Assistants.*—The duties of a junior assistant will consist mostly in tracing, lettering, and colouring drawings.

11. The duties of an assistant, and of a junior assistant, or *junior*, as he is generally called, will now be considered more in detail. A young man entering an office as a junior will begin by making tracings on paper or cloth. It is expected that he will be able to trace neatly and accurately in ink. While quickness is also desirable, accuracy and neatness are absolutely necessary, as the prints from which the contractor works are made by means of these tracings. The junior will also be expected to colour plans, and to make erasures and alter drawings skilfully. He may also, eventually, have to complete pencil drawings that have been commenced by one of the assistants, repeating certain features drawn by the latter. He should be able to letter a plan clearly and neatly. Proficiency in lettering will often be a help in improving his position. Among other duties would be that of accompanying an assistant when measurements have to be taken from some structure. He should be able to make simple measurements by himself and afterwards to plot them to scale.

12. When designs are to be prepared for a building, the preliminary sketches are usually made by the architect or his chief assistant according to his instructions. After the main features and methods of construction have been pencilled in on the working drawings, an assistant may be instructed to put in the windows, fireplaces, and details, working from the sketches and under the orders of the chief assistant. After these drawings have been approved, he would colour the plans, sections, and elevations, and such detail drawings that may require it. As the junior acquires experience his duties will gradually overlap those of an assistant, until he eventually is advanced to the latter position.

DRAWING-OFFICE STANDARDS

LETTERING

13. General Rules.—Considerable stress was laid in *Geometrical Drawing* on the necessity of learning how to letter neatly ; all that has been said there applies also to this Section, as any

proficiency acquired in lettering will be very useful in making working drawings. It is important that all sheets of drawing issued from a drawing office should have a uniform style of lettering, and that the various types of lettering be used always for one and the same purpose.

14. In the plates belonging to this Section, the lettering placed in the body of the drawing will be made according to the alphabet shown in Fig. 2. All the letters will be made free-hand, using a good, rather hard, steel writing pen having a

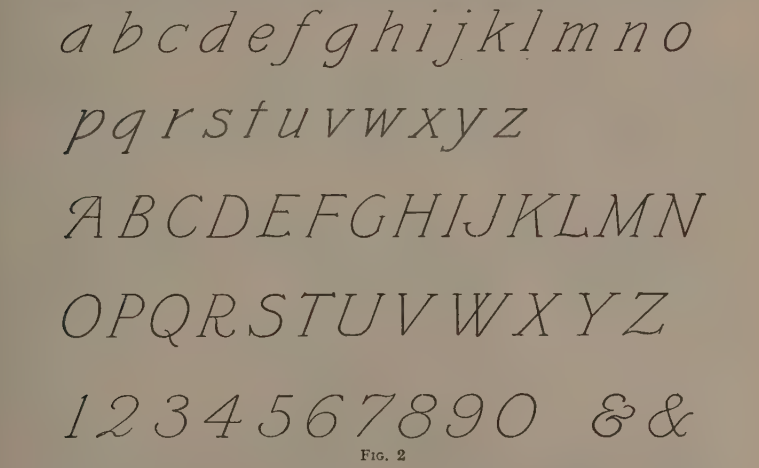


FIG. 2

point that is not too sharp. The general qualities of the pen should be those found in the No. 303 Gillott pen. It is advisable at all times to draw guide lines in pencil before the lettering is begun.

15. Single-Stroke Letters. — On all drawings showing, in general or in detail, constructive features, there are numerous notes and descriptive matter. The neatness of the drawing depends, to a considerable extent, on the lettering, both as to style and execution. The style that has become general on working drawings, on account of the rapidity with which it may be executed and its clearness and legibility, is known as

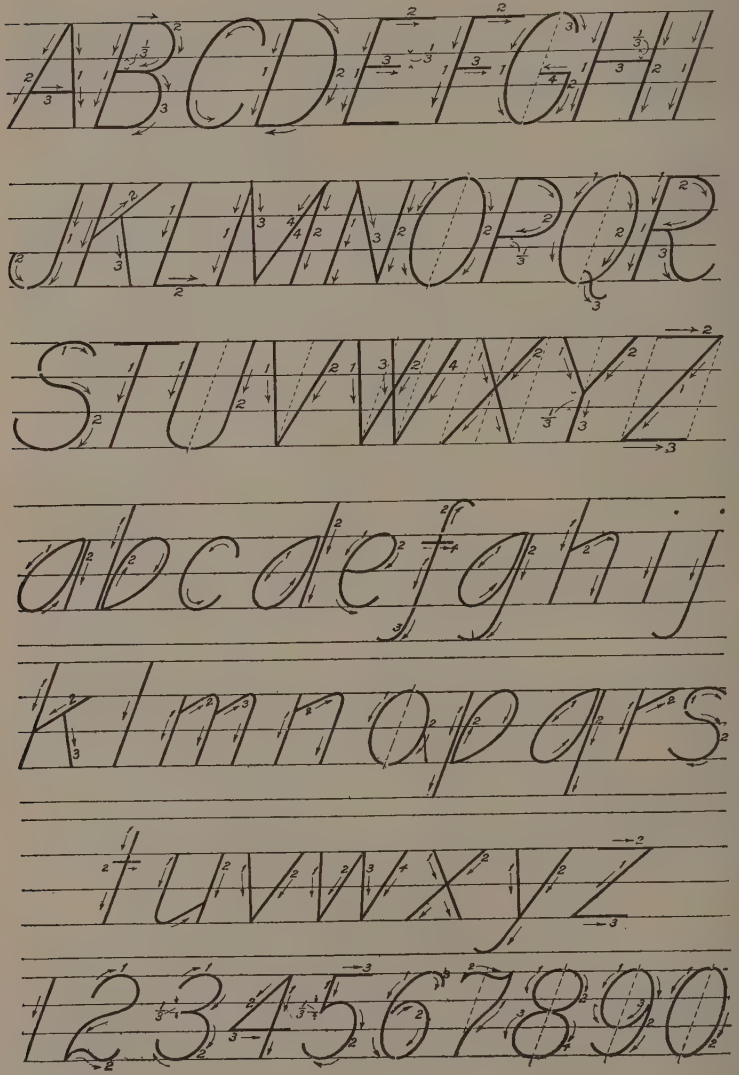


Fig 3

the **single stroke,** and is shown in Fig. 3. The manner in which these letters are made is clearly shown in Fig. 3, where the fundamental lines of the letters are the same as those used in Fig. 2. In Fig. 3 are shown the number of pen strokes in each letter as well as the direction and the order in which the strokes should be made. In some of the letters the distance between a transverse stroke and the nearest guide line is given in fractions of a space. Observe carefully the formation of the letters and follow the order and direction of the stroke given in the illustration.

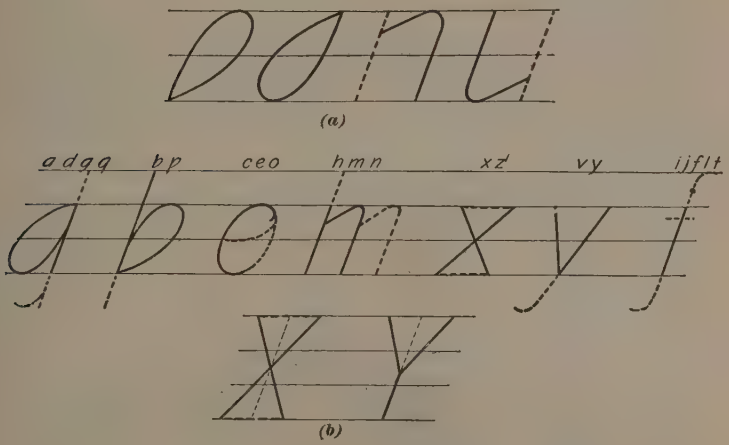


FIG. 4

Each stroke is numbered and the direction marked by arrows. It would be well to practise these letters assiduously and to make them at least the size shown in the illustration, for by so doing the attention will be directed to the crudities of the work, which will be magnified by the large size of the letters. Note particularly the construction of such capital letters as *K*, *R*, *V*, *W*, and *X*, and such small letters as *h*, *k*, *m*, *n*, *r*, and *u*, and be particularly observant of the numerals *7*, *8*, *9*, and *0*.

16. The alphabet shown in Fig. 3 should be practised until one becomes familiar with the formation and proportion of the

letters. The elements of the letters are formed by a single pen stroke, and when executed at a uniform angle and properly spaced they present a line of great neatness and legibility. The principles on which these letters are constructed are shown in the ovals of Fig. 4 (*a*), as are also the characteristic curves by which such letters as *m*, *n*, and *u* are joined at the top or bottom.

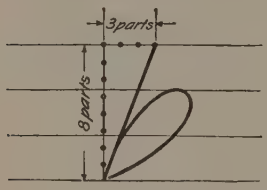


Fig. 5

At (*b*), the similarity of certain letters is shown, which if carefully noted will assist in obtaining uniformity in lettering. The best slant for the formation of the letters is that of the hypotenuse of a triangle having a side of 3 parts to a height of 8 parts, as shown in Fig. 5. In executing this lettering, the principal points to be observed are to keep the letters the same height and slant and as closely spaced as possible.

17. It is better, where neat lettering is required, to draw four equally spaced guide lines for the letters, as shown in Fig. 3.

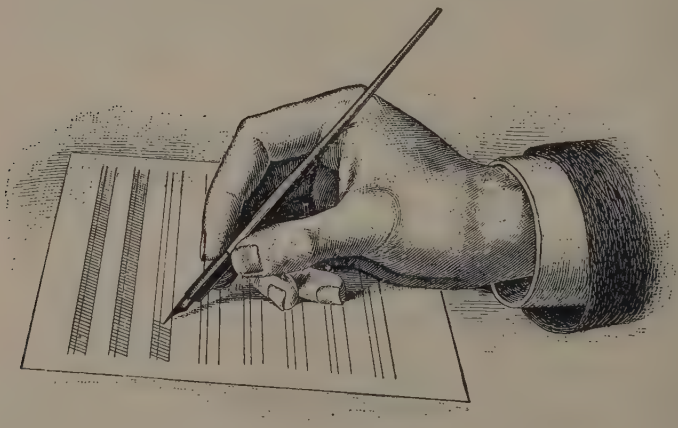


Fig. 6

The top line limits the height of the capitals and of such letters as *b*, *d*, *f*, *h*, *k*, *l*, etc.; the second line from the top determines the height of the small letters. Such letters as *g*, *j*, *p*, *q*, and *y*

FIG. 7

extend below the fourth line a distance equal to 1 space, that is, the space between each adjacent pair of guide lines. In practice, however, it is unnecessary to draw a line for this purpose, as these letters are usually so far apart that a slight deviation is indiscernible and the eye is a sufficient guide. A good exercise for becoming proficient in the execution of this type of lettering is shown in Fig. 6 ; it consists of drawing, freehand, numerous slanting lines about the height of the large letters, all parallel and at the proper angle with the horizontal.

18. After proficiency has been attained in writing the letters represented in Fig. 3, it will be easy to make the additions and variations required for writing the letters shown in Fig. 2. All of these letters, except *O*, *Q*, *e* and *o*, have been provided with *serifs*. A serif is a short cross-line added to the end of a stroke, as, for instance, at the foot of the down stroke of *a*, at the top of the down stroke of *b*, etc. The serifs on some of the capital letters may be overlooked where they, as in the *B*, appear simply as extensions of the curved strokes. Careful attention should be paid to the length and direction of all the serifs.

Variations in the form of the capital letters, shown in Fig. 3, are found particularly in the letters *E*, *L*, *R*, *W*, and *Z*, Fig. 2. Among the numbers, attention is called to the figures *2*, *3*, and *7*. Of the character &, called *ampersand*, two forms have been given, of which the first perhaps is the more ornamental, but also more difficult to make. Both should be practised.

19. Roman Alphabet.—The alphabet that is used for the titles on the plates is shown in Fig. 7 ; it is called a **Roman alphabet.** The purpose of the following description is to show the true form of the more difficult letters and how they are to be constructed ; but it is not to be understood that it will be necessary, in practice, to construct the letters in this careful manner. In an architectural office it would not be allowed to spend the necessary time for this purpose. Instead, the letters would all be outlined, approximately correct. by freehand ; but to do this successfully requires practice and a knowledge of the correct forms.

20. As seen from Fig. 7, all the letters are of uniform height, and this height is supposed to be divided into 9 equal parts. Horizontal lines drawn through these points of division, as in Fig. 7, will serve as an aid in fixing the positions and sizes of the important parts of the letters. Vertical lines spaced the same distance apart as the horizontal lines will serve to fix the width of each letter and also the thickness of its stroke. The horizontal guide line that passes through the base of a letter will be termed the **base line** and that through the top the **top line.**

21. The thick strokes of these letters, such as the rear stroke of the letter A, generally termed *down stroke,* will here be referred to simply as the **stroke.** The light stroke in the A and similar letters, usually called *up stroke,* will be termed the **thin stroke.** The term *serif* has already been defined. In letters drawn to a large scale, the curved part of a serif may be made with compasses set to a radius equal to the width of a stroke, as shown in Fig. 8. This construction applies only to vertical strokes ; for slanting strokes, such as are found in letters A, V, M, W, X, and Y, the radii of the serifs will vary in length and must be estimated by the eye, or the curve may be drawn freehand. The construction of the more difficult letters will now be taken up separately ; the method by which the others are drawn may be seen by examining Fig. 7.

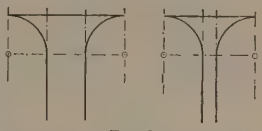


FIG. 8

22. Before beginning to draw the letters contained in a title, it is first necessary to choose a suitable height of the letters. This height should then be divided into 9 equal spaces ; through the points of division horizontal lines are drawn along the space to be occupied by the title. Instead of also drawing vertical lines across this space at a distance apart similar to the horizontal lines, it is preferable to take a square piece of stiff paper and to set off along one side a number of spaces equal to those between the horizontal lines. The required number of spaces that are to be occupied by a letter are set off from this piece of paper on to the base line. As the letters in a word are not equally spaced, this method has the advantage that the divisions

for any one letter can be set off where required irrespective of the divisions for another letter.

23. Letter A.—After the position of the letter has been fixed, then 9 spaces are set off on the base line, as shown in Fig. 9; points *a* and *b* will be the ends of the two strokes. At the centre of the fifth space from the left erect a vertical line and extend it to a point *c* $\frac{1}{2}$ space above the top line. Draw lines *a c* and *b c*, then draw another line *d* parallel to *a c* at a distance from it equal to one-third the width of a space, thus defining the thin stroke. Also draw a line *e* parallel to *b c* at a distance of 1 space. Hereafter it is to be understood that the thin stroke of any letter in this alphabet is to be $\frac{1}{3}$ space wide, and the stroke the width of 1 space. The lower line *f* of the cross-bar is drawn at a distance of 4 spaces above the base line; the cross-bar is of the same thickness as a thin stroke. The serifs are now defined by circular arcs having their centres at a_1, a_2, b_1, and b_2. Finally, the top of the letter is cut away by an arc with its centre at c_1 and a radius equal to 1 space.

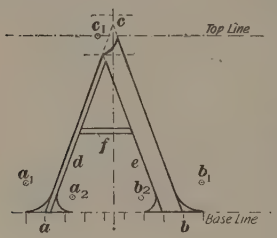


FIG. 9

24. Letter B.—Set off 7 spaces on the base line and at *b* and *c*, Fig. 10, erect the verticals *b a* and *c d*. By drawing parallels to *a d* and *b c* at a distance of $\frac{1}{3}$ space, the width of the thin strokes of the loops is defined. The position of the central thin stroke is fixed by the line *e f*, which is midway between *a d* and *b c*. From the centres *g* and *h*, distant 2 and 3 spaces, respectively, from line *a b*, describe semicircles tangent to the inside of the thin strokes, using a radius equal to about 2 spaces. The outside of the loops may be drawn freehand or circular arcs may be described from centres g_1 and h_1, 1 space to the right of *g* and *h*, respectively, and with radii equal to those of the inside arcs. It should be noted, however, that the outside semicircles cannot be continued beyond

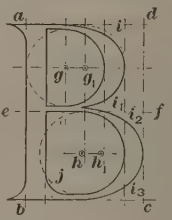


FIG. 10

the points i, i_1 and i_2, i_3; the remaining part of the curves must be drawn freehand. When these outside curves are drawn wholly freehand, care must be taken that they do not have too much of a shoulder at the points where they connect with the straight part of the thin stroke. A faulty curve of this kind is indicated by the dotted line at i. After describing a curve at j with a radius equal to 1 space, the two serifs may be drawn.

25. Letters C and G.—The letters C and G being similar to some extent, the construction of the former may be explained by means of Fig. 11. Set off 9 spaces on the base line and construct the rectangle $a\,b\,c\,d$, shown in dot-and-dash lines. At the centre e of the base erect the vertical $e\,g$; bisect this line at f and describe with the radius $e\,f$ the circle $e\,h\,g\,i$. The letter coincides entirely with the left-hand semicircle, but to the right of points e and g the curve becomes flatter, as shown by the curves $g\,j$ and $e\,k$. The inside curve of the letter is an ellipse that may be drawn freehand so that its major axis is vertical. Two short vertical lines at j and k, placed at a distance of 1 space from $c\,d$, complete the letter C, the lower half being equal to the upper one. Up to this point the letters C and G coincide. To make the necessary additions for constructing the letter G, draw a horizontal line l 3 spaces long and at a distance of $1\frac{1}{2}$ spaces below $h\,i$, and then draw a vertical at m 2 spaces to the left of $c\,d$. After describing the curves of the serifs the letter is complete.

Fig. 11

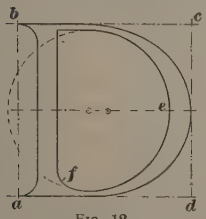


Fig. 12

26. Letter D.—Set off 9 spaces on the base line from a to d, Fig. 12, and construct the square $a\,b\,c\,d$. Draw the stroke at a distance of 1 space from $a\,b$ and draw parallels near the base line and top line to indicate the thin strokes. Tangent to the latter lines describe a circle that will pass through the point e, which is distant 1 space from $c\,d$. The lower inside line of the letter should be rounded off at f

and then the serifs added. The outer curve of the letter should be drawn freehand, as it does not form part of a circle, but is a semi-ellipse with its major axis horizontal.

27. Letter M.—To construct the letter M, Fig. 13, set off 12 spaces from *a* to *b* on the base line and then erect at *c* and *d* the verticals *c e* and *d f*. From point *g*, 1 space to the right of *e*, draw a line to *c*, and from *h*, 1 space to the right of *d*, draw a line *h f*. Then from a point *i* midway between *c* and *d* draw lines to *e* and *f*. These lines define the positions and inclinations of the various strokes. From the point *g* draw a line *g k* parallel to *e i* and at a distance of 1 space. Likewise, draw from *d* a line parallel to *h f*, and then, to form the thin strokes, draw the line *k l* parallel to *i f* and another line *m* parallel to *c g*. The main lines of the letter are now drawn and the serifs may be added in the usual manner.

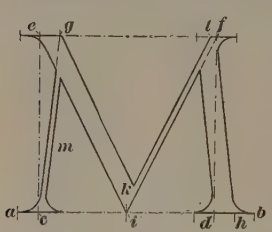


FIG. 13

28. Letter N.—Set off 9 spaces on the base line from *a* to *d* and construct the rectangle *a b c d*, Fig. 14. At *e*, 1 space to the right of *a*, erect the vertical *e f* and draw a line parallel to it to form a thin stroke. Draw also a parallel to the left of *c d* to form another thin stroke. From *g* where the line, just drawn, intersects the base line draw a line to *b*, then draw the line *h* parallel to *b g* to represent the stroke of the letter. The serifs are of the usual form except that at *b*, which is more than 1 space long and curves downwards.

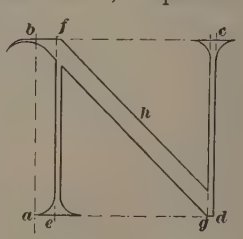


FIG. 14

29. Letter O.—Set off points *a*, *d*, Fig. 15, 9 spaces apart, construct the square *a b c d*, and inscribe in it a circle to form the outside of the letter. Draw the diagonals *a c* and *b d*, and on these as minor and major axes, respectively, construct an ellipse to define the opening of the letter. For letters of small

size, this ellipse should be drawn freehand. The thick and thin portions of the letter are of the usual widths.

30. Letter Q.—As shown in Fig. 16, the body of the letter is drawn the same as the letter O, except that the ellipse of the letter Q has its major axis vertical. To construct the tail, set off a point f midway between a_1 and b, and from f draw a line to e at the end of the major axis. Produce this line until it intersects at g a line drawn parallel to $b\,c$ and 3 spaces below it. The curved part of the tail is tangent to $e\,g$ at g, the lowest point on the curve being at a distance of 1 space from $h\,i$, while its end j is 7 spaces beyond the line $c\,d$, produced. Through the point k, 1 space above the base line, draw a line $k\,i$ parallel to $e\,g$ and continue it into the curve $i\,j$.

Fig. 15

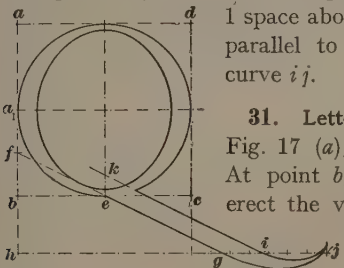


Fig. 16

31. Letter R. — The total width $a\,c$, Fig. 17 (*a*), of the letter R is 10 spaces. At point b, 1 space to the right of a, erect the vertical $b\,d$, and at j, 5 spaces from a, draw the vertical $j\,g$. The construction of the upper loop of this letter is similar to that of the letter B, except that in the former the lower thin stroke is below the horizontal centre line $e\,f$ instead of above

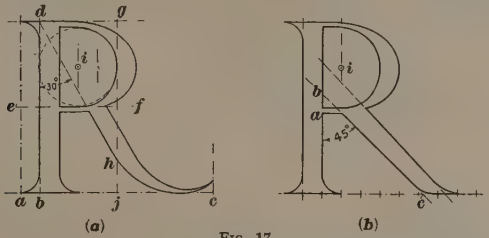


Fig. 17

it, as in B. The inner circle, shown as a dotted line, will therefore have a radius slightly larger than that in the letter B and

will have its centre *i* a distance of about 2 spaces from *b d*. The inclination of the tail can be determined by drawing from point *d* a line *d h* at an angle of 30° to *b d*. The curved part of the tail begins near the point *h*, the point of intersection between lines *g j* and *d h*. The straight part of the tail has a width about four-fifths of a stroke.

32. Some designers prefer a straight tail for the letter R, as shown in Fig. 17 (*b*). It may be drawn in the following manner: From point *a* on the under side of the loop set off the point *b* at a distance of 1 space, then draw a line *b c* at an angle of 45° to the stroke. The width of the tail may be equal to 1 space at its junction with the loop, tapering toward the base line to a width of $\frac{1}{8}$ space. The loop is drawn as in Fig. 17 (*a*).

33. Letter S.—This letter is 5 spaces wide. Erect from points *a* and *d* two verticals *a b* and *d c*, as shown in Fig. 18. Bisect *a d* and *a b* and draw the vertical and horizontal lines *e f* and *g h*, intersecting at *i*; then bisect *f i* at *k*, and with this point as a centre and *i k* as a radius describe the circle shown in dotted lines. Then set off point *l* at a distance from *e* equal to *a e*, and with *l* as centre and *e l* as radius describe the other circle, which is tangent to *a b* and *c d* at points *m* and *n*. Draw two lines at an angle of 30° to the base line and so as to be tangential to these circles at points *o* and *p*, respectively. The other lines of the letter may be drawn freehand, and curved as shown in Fig. 18. The short vertical line at *q* is 1 space from *c d*, while that at *m* is on the line *a b*. This construction will produce the necessary balance between the two loops.

Fig. 18

34. Letters U and Y.—In drawing the letter U, construct the rectangle *a b c d*, Fig. 19, 8 spaces wide for the body of the letter; in this rectangle the outer serifs are not included.

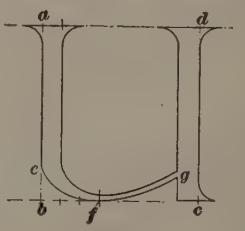


Fig. 19

The curve at the base of the letter begins at *e*, 2 spaces above the base line, and is tangent to this line at point *f*, 3 spaces to the right of *b*. The curve finally intersects the right-hand stroke at point *g*, which is $1\frac{1}{2}$ spaces above the base line. From points *f* to *g* this curved stroke is made the width of a thin stroke, while from *f* to *e* the width gradually increases to that of a full stroke. As shown from the detailed construction of the letter Y in Fig. 20, it has a width *a d* of 7 spaces exclusive of its serifs. Set off on the base line a distance *b c* of 7 spaces and erect the verticals *b a* and *c d*. Bisect *a d* at *f* and draw a vertical *f g* through this point; on this vertical set off point *e* at a distance of 4 spaces above the base line. Draw lines *a e* and *d e* and make the strokes of the usual width. The radii of the serifs on the inside of the slanting strokes will be smaller than those on the outside.

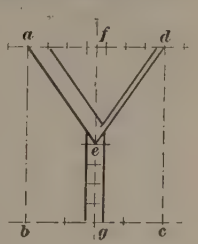


Fig. 20

35. Spacing of Roman Letter.—It is a simple matter to combine separate letters into words when the letters are of a rectangular form, such as block letters; but when the letters vary greatly in form, as is the case with the Roman alphabet, it will require some judgment to space them in such a manner that the spacing will appear uniform. If all the letters in this alphabet were approximately rectangular, as the letters shown in Fig. 21, then it would be possible to formulate a rule by means of which the spacing could be made uniform. But when letters have the outlines shown in Fig. 22 (*a*) and (*b*), such that the combination of the letters produces spaces that are irregular both in form and size, then it is not possible to regulate the spacing by any

HMN

Fig. 21

CDGJOP

(*a*)

FKLTVY

(*b*)

Fig. 22

rule. A few examples will make this clearer. In Fig. 23, the letters are approximately rectangular, and therefore, if an equal space is left between each letter, the spacing will appear to be uniform.

FIG. 23

36. The method used in Fig. 23 will not apply to the spacing of letters that consist of slanting strokes, as in Fig. 24. If the extreme points of the letters are projected to the base line, as shown by the short lines, and an equal space is left between every alternate pair of these lines, the result will be as shown in Fig. 24, where the first four letters appear to be too far apart. It may be supposed that this fault could be obviated by placing the letters L, A, and W closer together, as in Fig. 25 (*a*), but the space between the L and the A appears still too wide, and the only means by which this may be obviated is to move the letter W farther to the right, as shown in Fig. 25 (*b*). Though in the latter case there is, in reality, a greater distance between the letters A and W than between L and A, yet the letters seem to be evenly spaced.

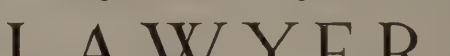
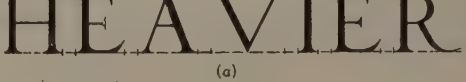


FIG. 24

(*a*) (*b*)

FIG. 25

37. Fig. 26 (*a*) is another example in which the projections of the letters on the base line have been evenly spaced. The result is that the open spaces between the letters E, A, V, and I are much too wide. In Fig. 26 (*b*), the word has been respaced so as to give the impression that there is an equal space between each letter. Some designers shorten the horizontal strokes of the letters in order to equalize the spacing,



(*a*)

(*b*)

FIG. 26

but this is not advisable and should not be done when there is room to allow the required separation of the other letters.

38. Particular care is required in spacing letters that consist of slanting strokes or have horizontal strokes at top or bottom. For instance, in Fig. 27 the letters L, T, and A are spaced by placing their projections on the base line equal distances apart. The result is that the letter T seems to stand between two separate words D E L and A S. A similar separation into two words results in Fig. 28 by placing the letter A too far from the letter N. On the other hand, the letters should never be allowed to touch unless absolutely necessary by reason of lack of space. Between adjacent words there should be a space at least equal to that occupied by a full-sized letter, such as the letter H, including its serifs.

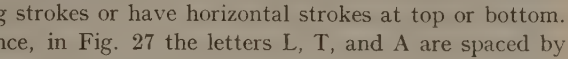


Fig. 27

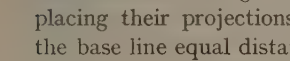


Fig. 28

39. The Roman alphabet does not appear to good advantage if the letters are spaced too close in each word. A method that may be followed in spacing the letters in practice is shown in Fig. 29, in which the main lines of the letters in the title Classic Mouldings are indicated in pencil. The number of points marked

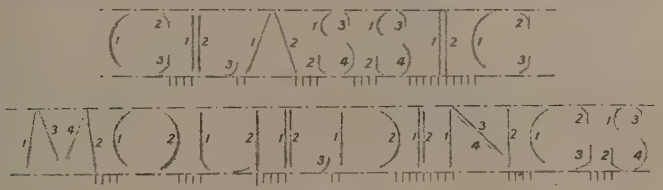


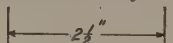
Fig. 29

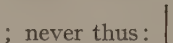
off on the base line indicate the number of spaces to be allowed between each letter, each of these spaces being equal to the width of a stroke. It is seen that the number of spaces here allowed vary with the different forms of the letters, and it may be necessary to sketch in the letters several times before a satisfactory result is obtained.

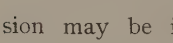
It must not be supposed that the amount of space allowed in this example between the letters will apply to similar letters in other words, as it has already been shown in Fig. 25 that the addition of some of the irregular letters requires the spacing of the whole word to be modified. The small figures placed on the letters indicate the order in which the strokes of each letter should be drawn. For instance, in the letter C the left-hand curve should be drawn first, then the upper curve to the right, and finally the lower curve.

DEFINITIONS OF LINES

40. Surface Lines.—Surface lines refer to those light full lines that represent the outline of an object; they should be of the same weight all over the figure.

41. Dimension Lines.—Dimension lines are lines drawn to show limits to which dimensions apply and are provided with an arrowhead at each end, put in freehand; the arrowheads should always touch the lines which limit the dimension, thus: 

; never thus: 

. A short dimension may be indicated thus: 

placing arrowheads outside of the limiting lines. The dimension figures should be placed where they can be read easily. Fig. 30 shows the various kinds of lines adopted and used in the following drawings. The dimension line consists of a series of long dashes, the interruptions preventing the line from being mistaken for a surface line, unless the latter is made heavier, as on the following plates.

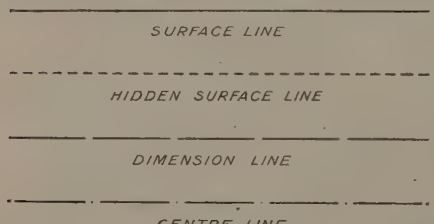


FIG. 30

42. Centre Lines.—In architectural drawings centre lines are, as a rule, not shown, unless a number of dimensions are to be

measured from the centre lines of some parts. These parts are usually so formed that the halves on either side of the centre line are symmetrical. Instances of this kind are the centre lines through the plans and elevations of doors, windows; plans of fireplaces, etc. A centre line is indicated by a dash-and-dot line, as shown in Fig. 30. This line is also used to indicate where a section has been or is to be taken.

43. Hidden Surface Lines. — **Hidden surface lines** are lines drawn to show the surfaces or edges of hidden parts, and it will be noticed that the part hidden in one view is sometimes drawn full in the other views, indicating that from one position the part cannot be seen, while from the other position it is in view. If hidden parts are to be indicated, they are always shown in dotted lines.

SECTIONS AND SECTION LINING

44. A structure is often drawn in section in order that its interior may be shown; or a structural part, as a window or door, is shown in section for the purpose of showing the cross-sections of some of the constituent parts. In either case the materials of which the parts in section are made are usually indicated by certain combinations of lines. Unfortunately, there is no universally adopted standard; thus, a certain combination of lines may indicate that the material is brick if drawn in one office; in another office this same combination may have been adopted to represent stone; and so on. As far as working drawings are concerned, there is usually no difficulty experienced on account of this diversity of practice, since the material is distinctly mentioned in the specification accompanying the drawings.

45. The most commonly used combinations of lines for different materials are shown in Fig. 31. Steel in section may be indicated by the grouping of lines inclined at 45° shown at (*a*). Brick is usually represented by lines, as at (*b*). Stone may be sectioned as shown in the upper or in the lower half of (*c*). Wood, when cut across the grain, is usually sectioned as shown in the upper part of (*d*), and when cut along the grain, as shown in the

lower part. Concrete may be indicated as at (*e*), and plaster as shown at (*f*).

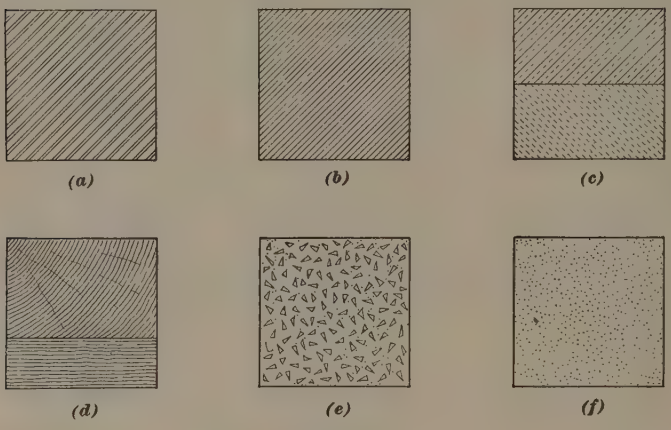


FIG. 31

46. Sections of other materials, as cast iron, wrought iron, brass, lead, etc., may be blacked in, as in Fig. 32, or indicated by means of various colours. In order to separate the different pieces, a narrow space is usually left between them, as shown in Fig. 32.

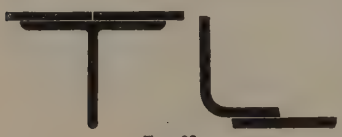


FIG. 32

It is preferable that the section lines on adjoining pieces made of the same material should incline in opposite directions, as in Fig. 31 (*c*). The fact that the pieces are separate is then brought out more clearly.

COLOURING OF ARCHITECTURAL DRAWING

47. Wash Work.—In architectural drawings, colour, or wash, work is used in various ways, instead of section lines, to indicate the material of which a part is made. The term **wash work** is used because the colour is laid over the drawing in thin transparent washes that permit the pencil or ink lines to show through after the colour is laid. These washes are of two kinds : (*a*) the

light transparent wash used to indicate surfaces, shown in plan or elevation ; and (*b*) the darker, more dense wash, to indicate surfaces in section. Thus, a light wash is used to colour door and window frames, panelling, stone and brick walls in an elevation, or floors of wood, stone, or brick, shown in a plan.

48. If in a plan or elevation some parts are shown in section, as, for instance, walls, partitions, window frames, etc., then the sectioned surfaces are covered with a darker-coloured wash than that used for indicating the same material when not in section. In some cases different colours are used for the light and dark washes. Where the surfaces shown in section are of relatively large areas, it would be a difficult and slow process to cover the whole surface with colour. In such cases it is customary only to outline the surfaces with narrow stripes of colour. An example of this kind is shown on the plate entitled *Full-Size Details.*

49. The purpose of colouring surfaces in this manner is that the different materials may be distinguished at a glance, and also to give the drawing a more pleasing appearance than if it were finished merely in black lines. There is no fixed rule among architects as to which colours are to represent different materials. The general tendency, however, is to make brickwork of a reddish, stonework of a greyish, and woodwork of a yellowish tint. Distinction is not alone made between different materials, but also between the condition of the surface of the same material. For instance, if the surface of a joist is unwrought, it is given a gamboge wash; if wrought, it receives a wash of vandyke brown. The term *wrought* is applied to woodwork that has been given a finished surface by planing. Woodwork without this finish is called *unwrought.*

50. Table of Colours.—The colours adopted for showing the materials on the plates included in this Section are given in Table I. In this combination such colours have been omitted that show a tendency to spot and give uneven tints. It is understood that the colours under the heading Surfaces are to be *thin* washes, and that these washes apply, in particular, to the

surfaces shown in the various plans, where the main object of the colouring is to make a distinction between different materials. When colouring surfaces, shown in elevation, more freedom in the selection of colours is allowed, as here the colouring serves more the purpose of giving an artistic finish to the drawing.

TABLE I

COLOURS USED ON ARCHITECTURAL DRAWINGS

Material	Sections	Surfaces
Brickwork	Scarlet lake	Scarlet lake
Wood (wrought)	Vandyke brown	Vandyke brown
Wood floors		Yellow ochre
Stone	Payne's grey	Payne's grey
Tiles		Scarlet lake and yellow ochre
Cement		Scarlet lake and Prussian blue
Plaster	Lampblack (light)	Hooker's green
Glass	Hooker's green	Prussian blue (very light)
Wood (unwrought)	Gamboge	
Iron	Prussian blue	Prussian blue

The surfaces in an elevation may therefore be given a tint that approaches more nearly their natural colour. For instance, stonework may be given a brownish tint, adding subsequently an occasional stroke of yellow. The roof tiles may be covered with a wash of red mixed with a little vandyke brown.

51. Laying On of Colour Washes.—If some skill has been acquired in laying on washes on large surfaces, there will be no difficulty in covering smaller ones, even with more dense colours, as the method followed is the same in each case. If, for instance, a large surface, as an outside wall, shown in elevation, is to be covered with a light wash so as to produce an even tint, the method pursued will be about as follows: To prepare the wash, put about a teaspoonful of water in a small saucer. Dip the brush, usually a No. 8 sable brush, in this and rub it gently on the cake of paint until some colour is taken up by the brush; there should not be so much water in the brush as to flood the

cake. Mix the colour adhering to the brush in the water contained in the saucer. Test the density of the colour on a piece of paper. If the colour is too strong, add more water; if too weak, add more colour. Then stir the water with the brush until all the paint has been well mixed with the water, and again test on a piece of paper before any attempt is made to colour the drawing.

52. For large areas, it is always best to moisten the area to be covered by means of a brush charged with pure water. Then, to ensure that the paper is evenly moist, lay a piece of white blotting paper over the damp surface and rub it gently. Care should be taken that the paper is not too moist when the wash work begins. The paper should not appear moist, but should feel so.

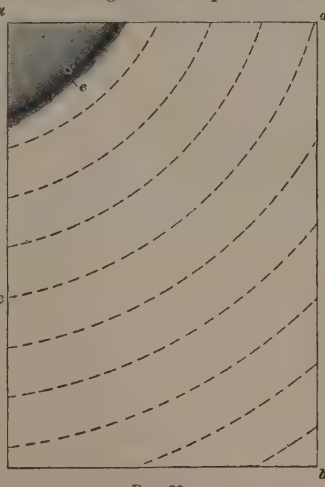


FIG. 33

53. The method followed in laying on a wash is shown in Fig. 33. After taking up as much colour in the brush as possible, apply it to the upper left-hand corner of the rectangle and form a pool there at *e*, as shown. Care should be taken that the wash does not extend over the edges. The drawing-board should be tilted so that with the aid of the brush the wash may be led to flow downwards gradually toward the lower right-hand corner. The wash should be guided along by a series of curved strokes, as indicated by the dotted lines in Fig. 33. After each stroke is made, the brush should be redipped in the saucer and the wash carried down with a liberal supply of liquid at its lower edge.

54. If the brush is not large enough to carry the entire pool across from side to side, as from *c* to *d*, it should be carried as far as possible and then redipped in the saucer. Under no

circumstances must the lower edge of the wash, that extends across the rectangle, be allowed to dry, for it will then leave a line of darker colour. In applying the wash, the contents of the saucer should be frequently stirred, otherwise the pigment, instead of being suspended in the water, tends to settle at the bottom, thereby making the wash, when applied, appear lighter in some places.

55. When the corner *b*, Fig. 33, is reached, the surplus colour may be taken up with a dry brush, or with one from which the colour has been extracted. Repeated application of the brush to a blotter and to the corner of the rectangle will remove all surplus fluid and leave the entire wash perfectly even. As the ability for laying on even washes is more a matter of practice than of skill, it is advisable to repeat this exercise several times before beginning to lay on any washes on the drawing plate.

As it is much easier to keep the lower border line of a wash sufficiently provided with colour when this border line is short, it is always preferable to wash across the most narrow part of the surface. When the surface is of moderate extent, it will not be necessary to moisten it before laying on the wash.

DRAWING PLATES

GENERAL INSTRUCTIONS

56. The general instructions which follow apply to all the drawing plates described in this Section.

From the start, the importance of neat and accurate work should be kept in mind ; also, that all lines, figures, and letters must be clear cut and distinct ; that there must be no doubt as to the meaning of limits or dimensions ; that mistakes made on drawings are often more serious than errors at the works, for they may not be found until the various parts of the structure are to be put in place. The necessity of making drawings concise, without making them needlessly complicated, must also be kept in mind ; likewise, that dimensions are not to be duplicated ; that when working drawings once have been presented

as finished and marked "complete," it should not be necessary to refer to the draughtsman for further particulars.

57. Size of Plates.—The plates are to be of the same size as those drawn in connection with *Geometrical Drawing*, 18″ × 14″, with border lines drawn $\frac{1}{2}$″ from the edges, making working limits of drawing 17″ × 13″.

58. Fractions.—Fractions are to be written with the dividing line horizontal, thus: $\frac{3}{4}$″, $\frac{7}{16}$″; never thus: 5/16″.

59. Dimensions. — All dimensions above 24″ are generally given in feet and inches, the feet being indicated by one accent (′) and the inches by two (″); a dash is inserted between the two values. Thus, 4 feet $6\frac{1}{2}$ inches is written 4′–$6\frac{1}{2}$″. If the dimension is a whole number of feet, a cipher is placed where the inches should be; thus, 3′–0″. Where possible, all dimensions should be written so as to be parallel to the bottom, or to the right-hand side of the drawing, and so that they may be read while either of these sides occupies the position of the bottom side of the drawings.

60. Measuring Strips.—Where it is necessary to duplicate a plan or to transfer partitions or other details from one plan to another, a **measuring strip**, consisting of a strip of paper about a foot long and $\frac{1}{2}$″ wide, can be conveniently used. The measuring strip is laid across the plan and held in position with the left hand while the positions of partitions, fireplaces, chimneys, stairs, doorways, and other desired details can be marked on the edge with the pencil. The measuring strip can then be laid on the other plan to which the various distances may be transferred.

61. Tracings. — In regular office practice it is necessary to have more than one copy of a drawing, but it would be very expensive to make a finished drawing every time an extra copy was wanted. To avoid this expense, a tracing is made of the drawing, and from this tracing blue- or black-line prints are made. Any number of prints can be made from a single tracing and at very little expense. The tracing may be made from an inked drawing or from a pencil drawing. In either case a piece

of tracing paper or tracing cloth, of a size slightly larger than the drawing, is fastened to the board over the original drawing. The tracing paper or cloth being transparent, the lines of the drawing can be readily seen through it, and the drawing pen can easily follow the lines. The process will therefore be similar to the inking in of the original drawing.

All ink lines on tracings must be uniformly black without regard to the width of these lines, in order to produce good prints. In general, the lines will be made heavier on the tracing than on the original paper drawing. At first, it will be found difficult to produce lines that are distinct and uniformly black. This is mostly caused by the fact that the drawing and compass pens are not well sharpened or that they are not held correctly. On inking in an ordinary drawing, these faults will not be so evident as on a tracing.

62. The two sides of the tracing cloth are known as the glazed side and the dull side. The glazed side is coated with a preparation of gelatine that gives it a very smooth glossy surface ; the dull side has very much the appearance of a piece of ordinary linen cloth. Either side may be used to draw on, but when the glazed side is used, care must be taken to remove all dirt and grease. This can be done by sifting powdered chalk on the tracing cloth and then rubbing it over the entire surface with a soft rag. It is not necessary to use chalk when the dull side is to be drawn on, but it improves the surface to do so, and causes it to take ink more readily. The finished drawing looks better and will not soil so easily if traced on the glazed side, and it is easier to erase a line drawn on this side. Pencil lines can be drawn on the dull side, and if it is desired to photograph the drawing, it is better to draw on the dull side. The draughtsman uses either side, according to the work he is doing and to suit his individual taste ; but if the glazed side is used, *it must be chalked*. The tracings are drawn in the same manner as the finished drawings, the centre lines, section lines, etc., being drawn exactly as previously described.

In general, tracings that are of less importance than the plans and elevations are made on tracing paper. To this class belong

full-size details. Sometimes tracings on tracing paper are executed in pencil instead of in ink, in particular if they are to be coloured afterwards.

63. Erasing.—As errors are sometimes made in a drawing, and changes are frequently necessary, **erasing** becomes one of the qualifications of a draughtsman. As a general rule, the marks of a soft pencil require a soft rubber for erasing. A close-grained rubber is usually poor, because it collects and absorbs the dirt and is too hard to rid itself of this by wearing away ; a rubber of this kind generally soils the drawing.

For erasing ink lines ink erasers are used, which are made from a mixture of powdered emery or glass and rubber. The action of the ink eraser is to remove the outer skin of the paper ; if, therefore, a line is to be erased from tracing cloth, care must be exercised, because the cloth will not suffer much rubbing before it is worn through. After an erasure is made on drawing paper, the gloss may be brought back by burnishing the spot with a smooth piece of ivory, such as the handle of a knife. When a smooth place is obtained in this manner the ink will not spread.

64. Cleaning of Drawings.—If a drawing is to be worked on for some time, it is sure to become soiled. This can be prevented to a certain extent by covering the work, excepting those portions on which the draughtsman is engaged, with transparent paper thoroughly secured to the edges so as not to interfere with the operation of the set-squares and the **T** square.

To minimize the accumulation of dirt on the drawing, the scales, set-squares, and **T** square should be carefully cleaned before commencing work, as most of the dirt collected on them is transferred to the drawing by their rubbing over its surface. For cleaning drawings, sponge rubber is by far the most effectual means. For removing dirt and pencil marks from tracing cloth, benzine may be used, it being applied by means of a piece of cloth. Care should be taken that the ink is a good waterproof ink, and that the benzine does not contain water, as otherwise the water will destroy the tracing cloth and the ink will be dissolved and flow.

DRAWING PLATE, TITLE: CLASSIC MOULDINGS

65. If a series of slabs of wood or stone, that is embedded in a wall, projects some distance beyond the main surface, or forms the top of the wall, it is customary to decorate the exposed angles of the stones with a number of ornamental cuttings, which, combined, form a moulded edge. These mouldings have various

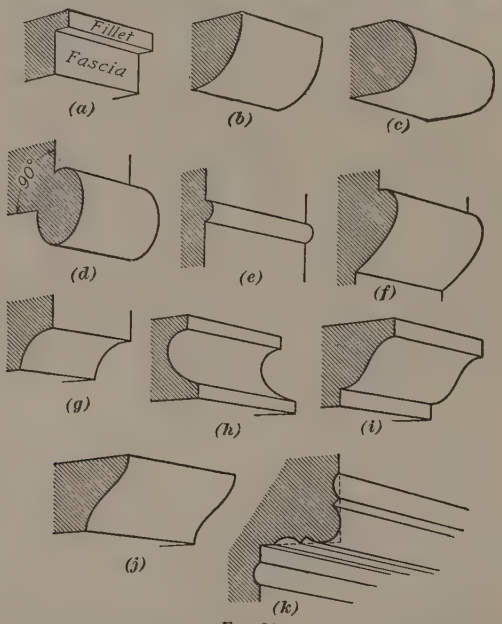


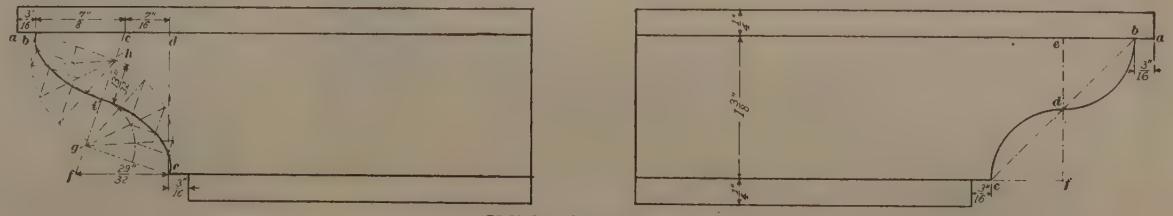
FIG. 34

names, according to their curvatures. The outline of a cross-section taken through a moulding is called its *profile*. A perfectly plain vertical surface projecting beyond another surface is called a *band* or a *face*. If the surface is a wide one it is termed a *fascia*, and a *fillet* if it is narrow, as shown in Fig. 34 (*a*).

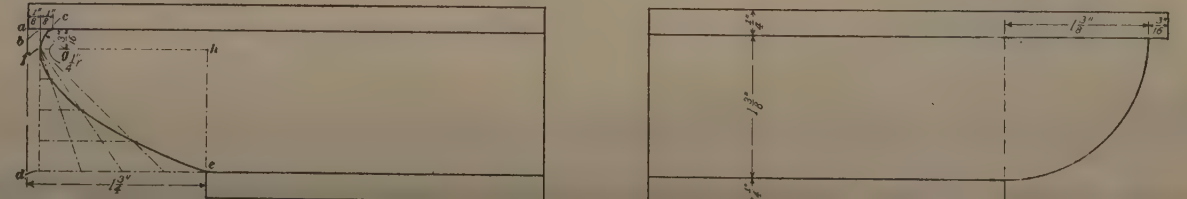
66. Names of Mouldings.—A simple convex moulding is called an *ovolo*, or a *quarter round*, when its profile represents one-quarter of a circle, ellipse, etc., as shown in Fig. 34 (*b*). It is

CLASSIC MOULDINGS

CYMA RECTA



CYMA REVERSA



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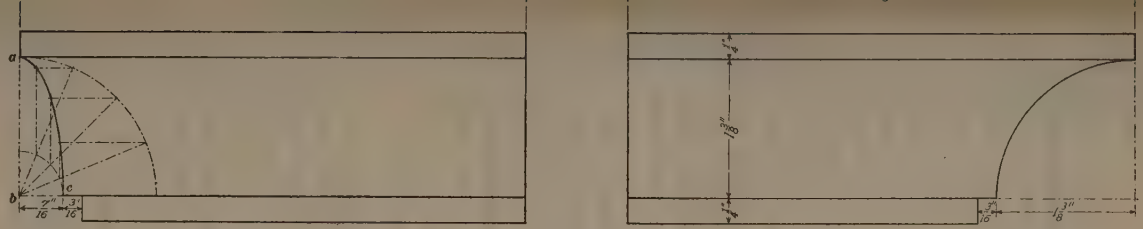
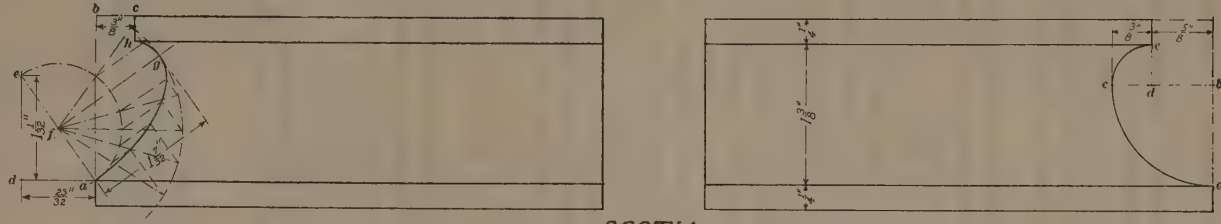


CAVETTO



SCOTIA

TORUS

GREEK ROMAN

called a *torus* when its profile represents one-half of a circle or ellipse, as shown at (*c*); and a *three-quarter round* when its form is as shown at (*d*). A very small convex moulding, as at (*e*), is called a *bead* or *astragal*, and an elliptic form of the torus moulding, as at (*f*), is sometimes called a *thumb* moulding.

67. The concave mouldings are the *cavetto*, at (*g*), and the *scotia*, at (*h*); their forms correspond closely to the reverse of the ovolo and the torus. In combining a convex and a concave moulding, another series, called *cymas* or wave mouldings, is produced. These are divided into two kinds: the *cyma recta*, as at (*i*), sometimes referred to as a *crown moulding*, owing to the fact that it is used principally at the top of a structure, and the *cyma reversa*, as at (*j*), often called an *ogee moulding*. All these mouldings were used by the ancient Greek and Roman architects, and are therefore called **classic mouldings.**

68. Besides the foregoing, there are other moulded forms, which were used by the architects of the Middle Ages, and these are usually termed **Gothic mouldings.** They were not worked on the projecting angle as in the classic mouldings, but on the planes forming the angle, as may be seen from Fig. 34 (*k*). They were cut into and lie below the surfaces of both planes. Sometimes the mouldings are cut on an oblique plane, instead of on a vertical and a horizontal plane, as in view (*k*).

69. This plate contains a series of classic mouldings and shows how each may be constructed geometrically. On comparing the Greek and Roman forms, it is seen that the latter are represented by one circular arc or by a combination of two arcs, while the Greek mouldings are based on such curves as the ellipse, the parabola, or on a combination of the two. By these means the Greek mouldings may be given more graceful profiles and are of a greater variety.

70. Commence this plate by drawing a vertical line through the centre of the lower border line dividing the plate into halves. On each side of this centre line draw a parallel line at a distance of $\frac{1}{2}''$. Also draw a vertical line $1''$ from each of the vertical

border lines. These vertical lines will determine the lengths and lateral positions of the mouldings. To fix the widths of the mouldings draw a horizontal 1″ below the top border line ; a space of $1\frac{7}{8}$″ is then set off and another horizontal drawn. These two lines will represent the upper and lower edges of the two upper mouldings. As the other mouldings also are $1\frac{7}{8}$″ wide, and as there is a $\frac{3}{4}$″ space between each pair of mouldings, the positions of their upper and lower edges may be fixed by drawing a series of horizontal lines spaced alternatively $1\frac{7}{8}$″ and $\frac{3}{4}$″ apart. All the mouldings have fillets $\frac{1}{4}$″ wide inside the top and bottom edges, therefore draw additional horizontals at this distance to represent the fillets.

71. The profile of the Greek cyma recta is a combination of two different curves, the upper half being part of an ellipse and the lower half part of a parabola. The methods followed in constructing either of these curves correspond to those given in *Geometrical Drawing*. Begin by placing a point *b* at a distance of $1\frac{3}{16}$″ from *a* ; draw a vertical through *b* intersecting the lower fillet at *c*, thus limiting the length of the latter. Produce the upper edge of this fillet toward *d* and draw a vertical through *a* intersecting line *c d* at *d*. On *d c* set off a distance of $\frac{3}{8}$″ from *d*, thus fixing point *e*. Draw a line *a e* and produce it toward *f*, and from *c* draw *c f* at right angles to *a f* intersecting it at *f*. Bisect *a f* at *g* and through this point draw the line *g j* at right angles to *a f*. On *g j* set off from *g* a distance of $\frac{3}{8}$″ determining the position of point *h*, the centre point of the profile.

72. The construction of the profile itself may now begin. In the elliptical part *a h* the lines *a g* and *g h* are halves of the major and minor axes, respectively ; using these as radii, describe the quadrants shown in the illustration and proceed to find points on the ellipse. To draw the parabolic curve draw *h i* and *c j* parallel to *g f* ; consider *h j* as the axis, and point *h* as the vertex of the curve, and find points on the parabola in the usual manner. The complete profile may now be drawn through the points ascertained by means of a French curve.

All the figures on this plate should be finished in pencil before the inking in of any one figure is begun.

73. To construct the Roman cyma recta, draw from point *a*, by means of a 45° set-square, the diagonal line *a b* inclined at an angle of 45° to the fillet and intersecting the upper edge of the lower fillet at *b*. Bisect *a b* at *c* and through this point draw the horizontal *d e*. Verticals through points *a* and *b* will cut line *d e* at *e* and *d*, which are the centres of the circular arcs *a c* and *b c*. After a short vertical is drawn through point *b* to limit the length of the lower fillet, the outline of this moulding is complete.

74. In the Greek cyma reversa the profile is composed of the arcs of two ellipses, which are constructed in the following manner: Set off from point *a* the points *b*, *c*, and *d* according to the dimensions given on the plate. Through *d* draw a vertical intersecting the lower fillet at *e*; produce the edge of this fillet from *e* toward *f* and set off *e f* equal to $\frac{29}{32}''$. Draw *c f*, and from points *b* and *e* draw lines *b h* and *e g* at right angles to *c f*, intersecting it at points *h* and *g*. From point *h* set off *h i* equal to $\frac{13}{32}''$; then *i* will be the point of junction of the two elliptical arcs. From point *h* describe quadrants with radii *h i* and *h b*, and from point *g* describe other quadrants with radii *g e* and *g i*; then proceed to construct the elliptical curves in the manner shown. Finally, by means of a French curve, draw the profile through the points ascertained.

75. Next proceed with the Roman cyma reversa by setting off from *a* a distance *a b* equal to $\frac{3}{16}''$, then draw *b c* at an angle of 45° to the horizon, the point *c* fixing the lower point of the profile. Bisect *b c* at *d* and draw the vertical *e d f*. Produce the edge of the lower fillet from *c* toward *f*; the points of intersection *e* and *f* will be the centres of the two quadrants that compose the profile, *d e* and *d f* being the radii of the upper and of the lower quadrant, respectively.

76. The main portion of the Greek-ovolo profile is a parabolic curve; its position may be found in the following manner: From *a* set off points *b* and *c* at the distances indicated on the plate, and from *b* draw a vertical intersecting at *d* the line *d e*, which is the edge of the lower fillet produced. On *b d* mark a

point f $\frac{3}{16}''$ below b and through f draw a horizontal intersecting at h a vertical drawn through e. Then, $f\,h$ is the axis of the parabola and f its vertex; it may now be drawn in the usual manner. The upper portion $f\,c$ of the profile may be made as a circular curve with a radius $f\,g$ of $\frac{1}{4}''$.

The profile of the Roman ovolo is simply a quadrant; the method of construction may be seen so clearly from the plate that no further explanation will be required.

77. To find the positions of the axes of the ellipse on which the profile of the Greek cavetto is based, proceed as follows: Draw through point a a vertical which intersects at b the continuation of the fillet edge. Set off $b\,c$ equal to $\frac{7}{16}''$, then describe the two quadrants with radii $a\,b$ and $b\,c$ and find points on the elliptical curve.

The construction of the Roman cavetto is the reverse of that of the Roman ovolo.

78. The profile of the Greek scotia is formed by a portion of an inclined ellipse, but there is no fixed standard as to the inclination and relative size of the axes in this ellipse. The inclination given to the axes of the ellipse on the drawing plate is fixed in the following manner: Draw a vertical through a intersecting the upper fillet at b, then set off point c at the required distance, and draw the line $c\,h$ as the end of the upper fillet. Extend the upper edge of the lower fillet and set off point d at a distance of $\frac{23}{32}''$ from a, then erect the vertical $d\,e$ and make it $1\frac{1}{32}''$ long. Draw the inclined line $a\,e$, and bisect $a\,e$ at f. Through f draw $f\,g$ at right angles to $a\,e$ and $1\frac{7}{32}''$ long; $f\,g$ is then one-half the major axis and $a\,e$ the minor axis of the ellipse. The elliptical curve may now be constructed as previously explained.

79. The Roman scotia is a compound circular curve constructed as follows: Draw through a the vertical $a\,b$ and fix the position of the centre b by setting off $a\,b$ equal to $\frac{3}{8}'' + \frac{5}{8}'' = 1''$. Draw the horizontal $b\,c$ and describe the arc $a\,c$ with radius $a\,b$. Set off point d $\frac{3}{8}''$ from c, draw the vertical $d\,e$, and with d as centre and $c\,d$ as radius, describe the arc $c\,e$.

80. The profile of the Greek torus is a reverse of the scotia. To find the position of the ellipse, set off from the vertical *a i*, which passes through the extreme point of the profile, the distances *a b* of $\frac{9}{16}''$ and *b c* of $\frac{1}{4}''$, thus fixing the positions of points *b* and *c*. The verticals *b d* and *c e* determine the lengths of the lower and upper fillets. Set off the distance *d f* of $\frac{13}{16}''$ and draw the line *f e*; from *e* set off *e g*, the minor axis of the ellipse, equal to $1\frac{11}{32}''$. Bisect *e g* at *h* and from this point draw *h i* at right angles to *e g* and $1\frac{1}{8}''$ long. The required portion of the ellipse may now be constructed.

The profile of the Roman torus is a semicircle of $\frac{11}{16}''$ radius.

81. The figures are now all drawn in pencil and the inking in may be proceeded with. All the curves in a figure should be inked first, then the horizontal, vertical, and oblique lines in the order given. When all the figures have been inked, the drawing plate should be cleaned and the dimension lines with the corresponding dimension figures inserted. It is advisable first to draw the dimension lines in pencil and then to add the dimensions, also written in pencil. During the inking of the dimension lines it is possible to leave sufficient space at the centre of each for the insertion of the dimensions. If any part of a figure is shown in section, as will be the case with some of the succeeding plates, the section lines should be put in last. By doing so, sufficient space will be provided for dimensions that may have to be placed on the sectioned surface. After this the names of the mouldings and the title should be inserted. To serve as a base line for the names, draw horizontal lines at a distance of $\frac{5}{16}''$ below the lower edges of the mouldings and at the centre space between each pair of mouldings; at a distance of $\frac{3}{16}''$ above these lines draw others to limit the height of the letters. The forms of these letters should conform to those in the alphabet, Fig. 2.

82. The letters in the words *Greek* and *Roman* should be $\frac{3}{8}''$ high, and a space of $\frac{5}{16}''$ should be left above and below them. The main title consists of letters $\frac{1}{2}''$ high with spaces of $\frac{1}{4}''$ above and below. The form and position of each letter should first be indicated in pencil so that their positions may be changed until the spacing appears to be uniform. After the lettering has been

completed the border lines should be inked in ; then the name of the student, his class letters and number, and the date when the drawing was finished should be added.

DRAWING PLATE, TITLE: DESCRIPTION OF ARCHES

83. The diagrams on this plate are given to indicate the geometrical methods of setting out the several kinds of arches commonly used in building construction. *In order to distinguish readily between references to figure numbers on the drawing plates and to those in the text, the former will be printed in heavy-face type and the latter in ordinary type.* Figs. **1, 2,** and **3** are known as *semicircular*, *segmental*, and *elliptic* arches, respectively. Fig. **4** is a *segmental pointed* arch ; other pointed arches are shown in Figs. **5, 6,** and **7.** These are, according to the proportions given them, designated as *equilateral*, as in Fig. **5,** *acute-angled*, or *lancet*, Fig. **6,** and *obtuse-angled*, Fig. **7.** A *Tudor, four-centred* arch is shown in Fig. **8,** and an *ogee* arch in Fig. **9.** Figs. **10** and **11** are termed *horseshoe* arches.

84. The diagrams are arranged symmetrically with reference to the vertical centre line of the plate ; their positions may be fixed in the following manner : Draw the vertical centre line of the plate, and at a distance of $2\frac{1}{2}''$ from each of the vertical border lines draw two other vertical lines. These three lines serve as centre lines of the diagrams. To fix the positions of the upper and lower boundary lines of the diagrams draw a series of horizontal lines spaced as follows : The top points of Figs. **1, 2,** and **3** should lie on a horizontal line $1\frac{1}{2}''$ below the top border line. As all the diagrams have a height of $2\frac{3}{4}''$, draw another horizontal $2\frac{3}{4}''$ below the first to serve as a base line. Between this base line and the horizontal passing through the top points of the diagrams in the next row leave a space of $1''$. The positions of the succeeding rows are fixed by drawing horizontals spaced alternately $2\frac{3}{4}''$ and $1''$ apart. Finally, draw below the base line of each row a supplementary horizontal to indicate the positions of the dimension lines for the spans.

DESCRIPTION OF ARCHES

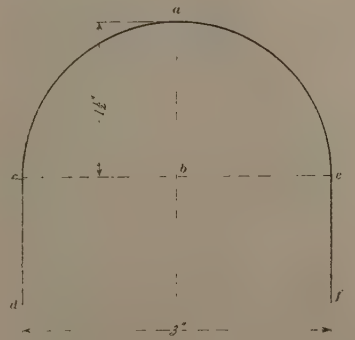


Fig. 1

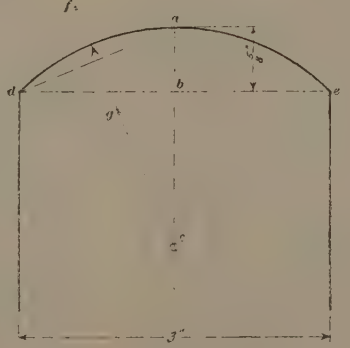


Fig. 2

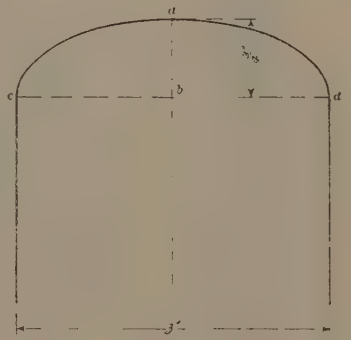
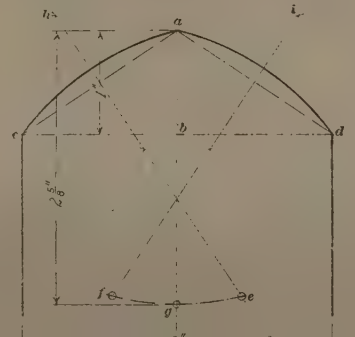
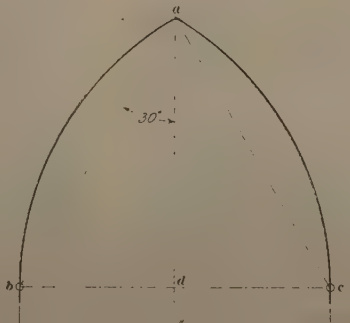
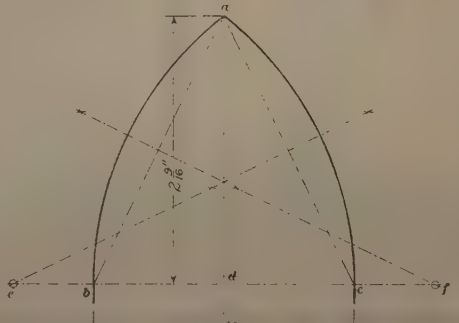


Fig. 3







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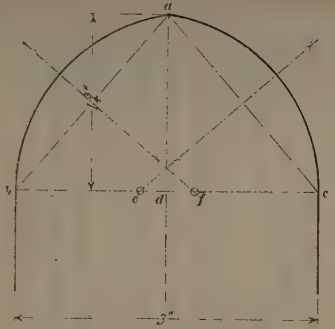

Fig. 7

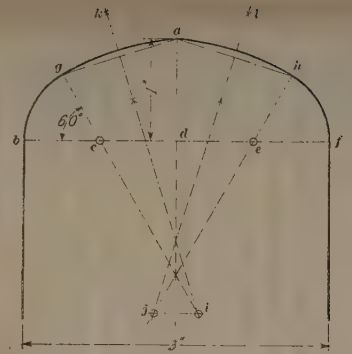

Fig. 8

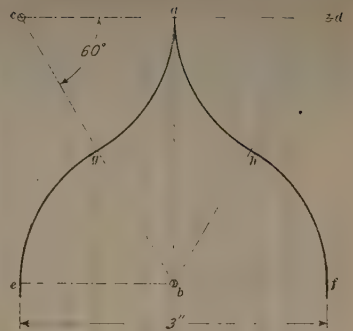

Fig. 9

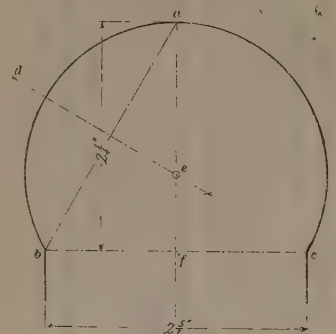

Fig. 10

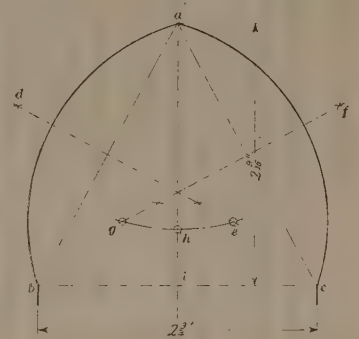

Fig. 11

85. The principal dimensions required for the construction of an arch are the rise and the span. Therefore, in beginning to draw Fig. **1,** set off from *a* the rise *a b* of $1\frac{1}{2}''$, and through *b* draw the springing line *c b e*. Then, with *b* as centre, describe the semicircle *c a e*, and through *c* and *e* draw the verticals *c d* and *e f* to represent the sides of the opening.

86. Fig. **2** is commenced by setting off from *a* the rise *a b* of $\frac{5}{8}''$, then through *b* draw the springing line *d e*, making the parts *b d* and *b e* each equal to $1\frac{1}{2}''$. Through *d* and *e* draw verticals representing the sides of the opening. It is now necessary to find the radius of an arc that will pass through the points *d*, *a*, *e*. For this purpose the chord *d a* is drawn, and as it is known that a line drawn from the centre of the chord, and at right angles to it, will pass through the centre of the arc *d a*, find in the usual manner two points *f* and *g* and draw the line *f g c*. It follows that the point *c*, where *f g c* and *a b c* intersect, must be the required centre of the arch. Therefore, with *c* as centre and *a c* as radius, describe the arch *d a e*.

87. The arch, Fig. **3,** is a semiellipse in which the rise *a b* is one-half of the short diameter and the springing line *c d* the long diameter. Set off from *a* the rise *a b* of $\frac{3}{4}''$ and through *b* draw the springing line *c b d* of the required length. The semiellipse may now be constructed according to the method used on the preceding plate.

88. Fig. 35 shows an alternative method of constructing an ellipse on a larger scale, which is often found useful in practice. In Fig. 35 (*a*) the line *a b* is equal to one-half of the short diameter, while *c d* represents the long diameter. It is first necessary to find the positions of points *e* and *f*, termed the *foci* of the ellipse, by describing, with *a* as a centre and *b c* as radius, two short arcs intersecting *c d* at *e* and *f*. Pins are now placed at the latter points and, provisionally, also at *c*. A piece of string is then provided with a loop at one end and this is placed over the pin at *e*, as shown diagrammatically in Fig. 35 (*b*). The string is then drawn round the pin at *c* and from there stretched toward the pin at *f*, where another loop is made and

placed over this pin. The amount of tension given the string will depend on its elasticity ; it is preferable to use one that is not too elastic.

89. The pin at *c* is now removed and replaced by the point of the pencil with which the ellipse is to be described. For this purpose the pencil is held at right angles to the paper, board, or other surface on which the drawing is to be made. Referring to Fig. 35 (*c*), it is necessary, while moving the pencil from *c* to *d*, to exert a pull away from the foci so as to keep the string uniformly taut. Two of the positions that the pencil successively occupies, while moving toward *d*, are shown at *h* and *i*, the corresponding positions of the string being indicated by the dotted lines *e h*, *h f* and *e i*, *i f*. When the pencil reaches point *d* it has described the semiellipse *c h i d*. By repeating the process on the lower side of the long diameter, the other half of the ellipse may be drawn.

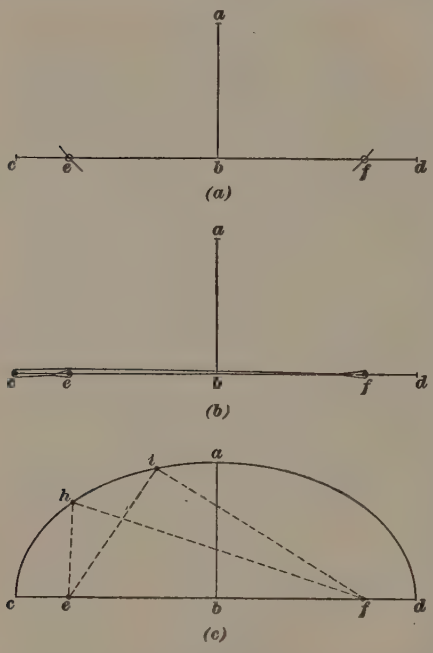

FIG. 35

90. In the segmental pointed arch, Fig. 4, the rise *a b* is 1″ ; set off this distance from *a* and draw through *b* the springing line *c d* 3″ long ; also the chords *c a* and *a d*. Find by the usual method the positions of lines *h e* and *f i* which pass through the centres of the arcs *c a*, *a d*. The lengths of the radii for these

arcs depend on the curvature it is desired to give them ; in this example the radius of each is to be $2\frac{5}{8}''$. Therefore, set off *a g* equal to this length, and with *a* as centre describe an arc that intersects *e h* and *f i* at points *e* and *f*. These points are the centres of the segmental arcs, which may now be described.

91. The variation in the forms of the pointed arches, Figs. **5, 6,** and **7,** is caused by changing the ratio between the span and the rise. In Fig. **5** the chords *a b* and *a c* are equal to the length of the springing line *b c* ; the triangle *a b c* is therefore equilateral. Commence the diagram by drawing from *a* the chords *a b* and *a c*, each inclining to *a d* at an angle of 30°. Through points *b*, *c*, where the chords intersect the verticals that limit the width of the opening, draw the springing line *b c*. The centres of the arcs *a b* and *a c* are at *c* and *b*, respectively.

92. In Fig. **6** the rise and the span are nearly equal, thus giving this pointed arch the special form called *lancet* arch. Set off from *a* to *d* the rise of $2\frac{9}{16}''$ and through *d* draw the horizontal *e f* ; also set off the points *b* and *c* at the required distances from *d*. Draw the chords *a b* and *a c* and construct lines passing through the centres of the chords and at right angles to them ; these lines intersect line *e f* at *e* and *f*. The latter points are the centres of the segmental arcs.

93. In Fig. **7** the rise is considerably less than the span ; the upper part of the arch will therefore appear more flat. The construction of this arch is similar to that shown in Fig. **6.** First set off the rise *a d* equal to $1\frac{3}{4}''$ and draw the springing line *b d c*, also the chords *b a* and *a c*. In the usual manner, erect lines at right angles to the chords at their centres and produce them so as to intersect the springing line *b c* at *e* and *f* ; the latter points are the centres of the segmental arcs *a c*, *b a*.

94. To draw the four-centred arch, Fig. **8,** set off from *a* a rise *a d* of 1″ and draw the horizontal *b d f*. Divide this line into 4 equal parts *b c*, *c d*, *d e*, and *e f*, then through points *c* and *e* draw lines *c g* and *e h* at angles of 60° to *b f*. Erect lines *i k* and *j l* at right angles to the chords *g a* and *a h*, and produce *g c* and *h e* so as to intersect *i k* and *j l* at *i* and *j*. If

correctly drawn, then a horizontal through point *j* should also pass through *i*. Points *c*, *j*, *i*, and *e* are the centres of the arch. In describing the arcs, begin arcs *a g* and *a h* at point *a*, then describe at both sides the smaller arcs *g b* and *h f*.

95. In the true ogee arch, Fig. **9,** there is a definite ratio between the rise and the span ; this ratio may be found by geometrical construction in the following manner : Through point *a* draw the horizontal *c d* and set off *a c* and *a d*, each equal to one-half the span, in this case $\frac{3}{2}'' = 1\frac{1}{2}''$. Draw *c b* and *d b* at an angle of 60° to *c d*, and through their point of intersection, which must lie on the centre line *a b*, draw the springing line *e b f* ; the points *b*, *c*, and *d* are the centres of the arch. Describe first the arcs *a g* and *a h*, from centres *c* and *d*, then from centre *b* the adjoining arcs *g e* and *h f*.

96. To draw the horseshoe arch, Fig. **10,** set off *a f* equal to the rise of $2\frac{1}{4}''$, and draw the springing line *b f c*. Erect a line *d e* at right angles to the chord *a b* at its centre. The line *d e* will intersect *a f* at *e*, the centre of the arc *b a c*.

97. The other horseshoe arch, Fig. **11,** is drawn as follows : Set off from *a* the rise *a i* and draw the springing line *b i c*. By the usual construction draw lines *d e* and *f g* at right angles to the chords *b a* and *a c*, then with *a* as centre and a radius *a h* of 2″ describe an arc intersecting lines *d e* and *f g* at points *e* and *g*, the required centres of the arcs *b a* and *a c*.

98. The diagrams may now be inked in, describing in each example first the curves before beginning with the straight lines. All reference letters are to be omitted. When the diagrams are completed, the dimension lines with the dimensions are added. The dimension lines for the spans should be drawn on the pencil lines provided for them below the base lines of the diagrams. Draw horizontal lines at a distance of $\frac{5}{16}''$ below the dimension lines for the spans, to serve as base lines for the figure numbers, and $\frac{3}{32}''$ and $\frac{1}{8}''$ above these base lines draw other horizontals to limit the heights of the small letters and of the capitals, respectively. Finally, draw two lines parallel to the top border line at distances of $\frac{1}{4}''$ and $\frac{3}{4}''$ for the title of the plate.

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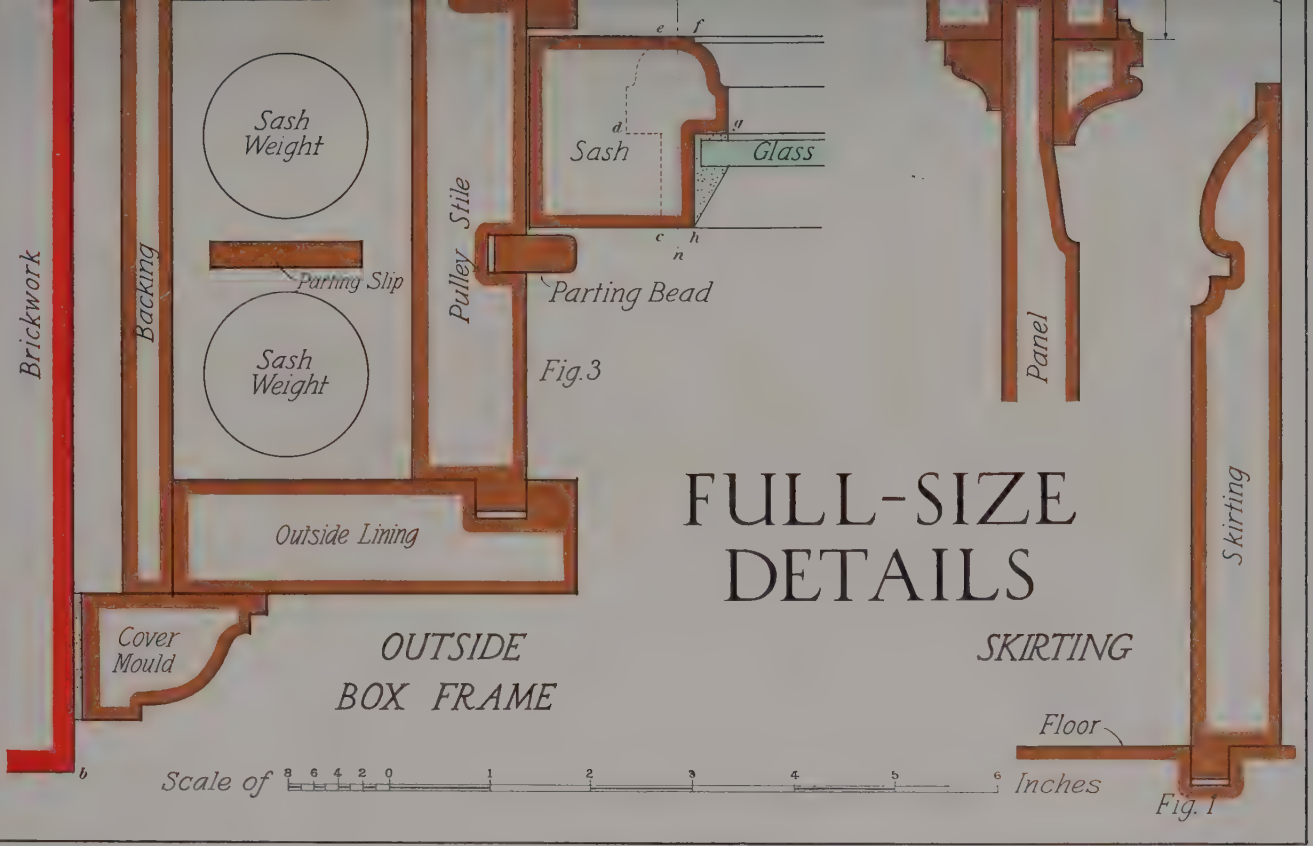


DRAWING PLATE, TITLE: FULL-SIZE DETAILS

99. The following drawing plates show the details, plans, and elevations of a two-story building. Perspective views of the front and the back of this building are shown in Figs. 36 and 37. By consulting these views whenever some parts of the drawing plates are not fully understood, there should be no difficulty in forming a clear idea of the actual construction of the building. There are also inserted in the text some plans and elevations that are not to be drawn, but which, in practice, would be included among the required working drawings to give complete information regarding the building.

100. It is necessary to emphasize the fact that the house, as shown in these drawings, is not to be considered as an example in design. The reason for this is that the house contains several features that are rarely combined in one of that type. Among these features may be mentioned the mullion windows and the timber gable. These and other features have intentionally been included in the design for the purpose of providing practice for drawing similar parts when required in other designs. The first drawing plate of this series contains three views of some full-size details of skirtings, doors, and windows which are to be used in the building. By means of the scale at the lower border line of the plate it is possible to ascertain the dimensions of the several parts, and, since the details are set out full size, an ordinary foot-rule is used in making the drawing.

101. Fig. **1** shows a moulded **skirting,** which is the finish placed round the bottom of a wall or partition, and, resting on the floor, forms a protection for the plaster. Place the line representing the face of the plaster $\frac{1}{4}''$ from the right-hand border line, and the floor line 1″ above the lower border line. Great care should be exercised in order to obtain the correct profile of the mouldings, as otherwise they may lose character and beauty of outline.

102. Fig. **2** is a plan taken through a portion of a door and its jamb; as the several parts are indicated by name, no

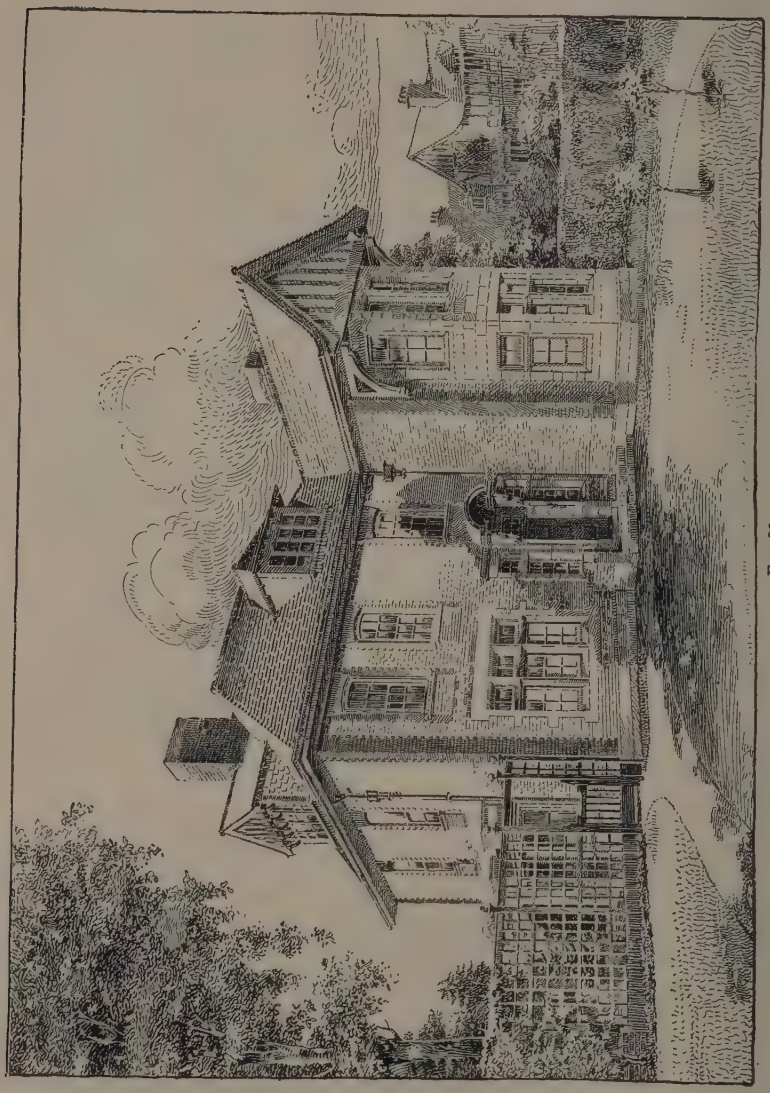


FIG. 36

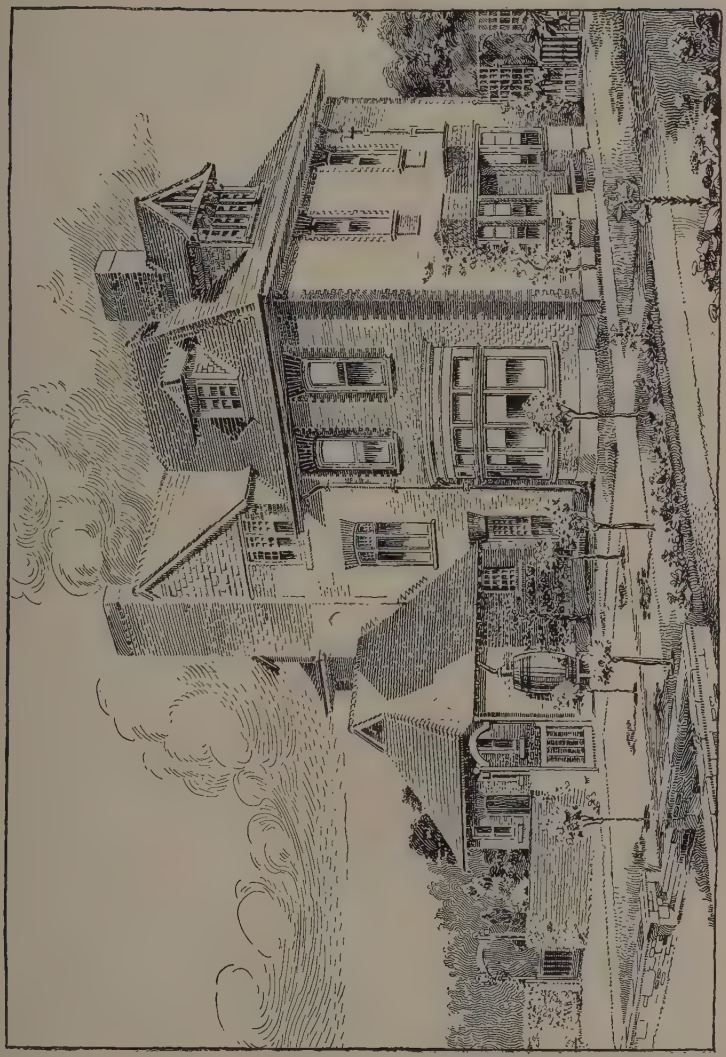


FIG. 37

further explanation is required. The side *a b* of the wall is placed $3\frac{1}{2}''$ below the upper border line, and the face *b c* $2\frac{3}{8}''$ from the right-hand border line, leaving a space of $4\frac{1}{2}''$ between the faces *b c* and *a d*. It is understood that the dimension 9″ means the full thickness of the wall, but in this case the central part of the wall has been removed for the purpose of gaining space for the adjoining parts without increasing the size of the drawing plate. A different construction is shown on the two sides of the wall, as only on one side the architrave is joined to a panelling. Having fixed the principal lines of the figure, the several parts may be drawn to scale.

103. Fig. **3** shows the usual method of constructing a sash window frame of an ordinary dwelling. Place the line *a b* $\frac{7}{8}''$ from the left-hand border line, and point *b* a distance of $\frac{3}{4}''$ above the lower border line. As every part is clearly indicated by name, its purpose and the material of which it is made are known. The only part that requires some explanation is the figure arranged symmetrically round the centre line *m n*. The line *f g h* represents the sash moulding at one side, but the figure *c d e f g h* represents the section of the glazing bar that is placed between two adjoining panes of glass. There may be several bars in one sash depending on the number of panes.

104. These views are not to be inked in, but are to be left in pencil and then coloured. It is therefore necessary that, before the colouring begins, the pencil lines should be examined, erasing superfluous lines and improving ragged lines. If the curved lines of the mouldings are thick and uneven, they should be rubbed over with the eraser until only faint lines remain ; these lines are then gone over again with the pencil. The letters in the main title may now be drawn, placing the base lines at a distance of $2\frac{3}{8}''$ and $3\frac{1}{8}''$, respectively, above the lower border line and making the letters $\frac{1}{2}''$ high. Before inserting the names on the parts, it is advisable to rule a series of lines $\frac{1}{8}''$ apart between which the letters may be inserted. All reference letters are to be omitted. After all the powder, resulting from the erasures, has been well brushed off, the plate may be coloured according to the directions given herewith.

105. As nearly all the surfaces on this plate represent sections, they should, according to the rules, be covered with colour washes. But the sectioned areas being too large conveniently to be covered entirely, it is customary in such cases to indicate the material only by narrow stripes of colour along the outlines of the various surfaces. The average width of these stripes may be $\frac{1}{8}''$, except in the section through the brick wall, which is made more prominent by making the colour stripes somewhat wider, or about $\frac{3}{16}''$.

106. If these stripes were made by beginning at one corner and continuing along the outline of the section to the starting point, there would be a dark line at the place of junction where the end of the stripe joins the beginning. There are two methods by which this may be avoided, one of which is as follows: To colour the skirting, Fig. **1**, the beginning would be made in the upper corner from where two stripes would branch off, one to the left and one to the right. These stripes would be continued alternatively downwards to the lowest point, where both would join without showing any line of junction. In the other method, which is particularly suitable for large areas, no attempt is made to produce an invisible joint of the stripes; the two ends of the stripe are not allowed to touch, a narrow white space being left between them. When well done this is scarcely noticeable, and it can, when the colour is entirely dry, be eliminated by a line made with a nearly dry brush. If, while using either of these methods, there should remain too much colour in the stripe near the end, it may be removed by touching the stripe carefully with a brush that has previously been passed over a piece of blotting paper. The colour removed by the brush is transferred to the blotting paper, and this process may be repeated, if necessary.

There are some exceptions to the rule that the stripes should be of uniform width all over a section. For instance, when parallel parts of the stripes in some parts of the moulding pass so close together that there is less than the width of the stripe between them, then the separate parts of the stripe should be joined into one. There are several instances of this kind on the plate. Small areas where only a little white space remains inside

the stripe would, as a rule, also be covered entirely with a colour wash.

107. The colours to be used on this plate are specified in Table I, and are also shown on the specimen plate. As regards the density of the colours, it is better to err by making them too light than too dark, as in the first case it will be easier to make an even-coloured stripe and the plate will also appear to better advantage.

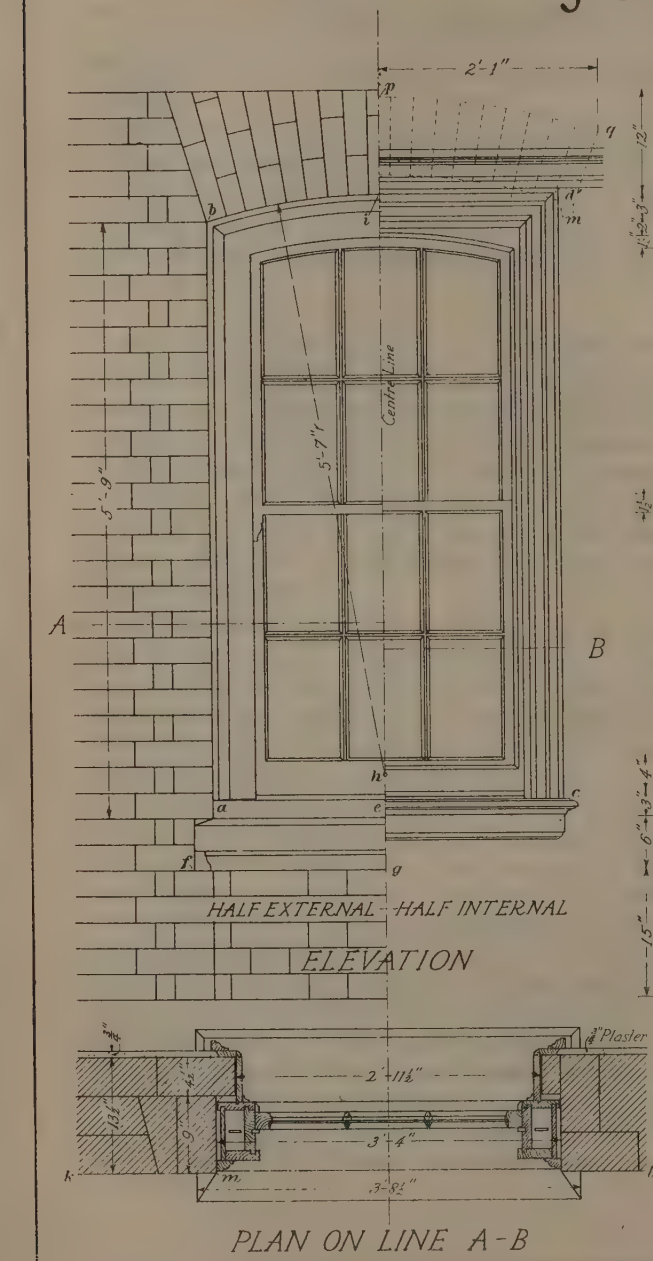
DRAWING PLATE, TITLE: JOINERY DETAILS

108. On this plate are shown elevations, sections, and plans of a door and window to be used in the two-story building already referred to. Full-size details of some of the parts are found on the plate *Full-Size Details*, and the latter are to be used to supply some of the dimensions required in the plate now to be drawn.

All the dimensions in the text that refer to the positions on the drawing plate of the various details, their centre lines, etc., are full-size dimensions.

109. Begin this plate with the elevation of the window, which with the other details is drawn to a scale of 1″ = 1 ft. It is to be noted that this elevation combines the external and internal elevations of the window into one, the half-elevation to the left of the centre line showing the external and that to the right the internal elevation. Draw first the centre line at a distance of $3\frac{3}{8}$″ from the left-hand border line, then set off to the left at a distance of 20″ the brick jamb *a b*, placing the point *a* $4\frac{3}{8}$″ above the lower border line. Make the jamb 5′ 9″ high and draw the base line *a e*. With a radius of 5′ 7″ and with *b* as a centre describe a short arc intersecting the centre line at *h*, which point will be the centre of the arc *b i*. Draw the bottom bed *f g* of the stone window sill at a distance of 6″ below *a e*, as shown in the vertical section. Now draw the plan of the window and wall, placing the outside wall line *k l* $\frac{15}{16}$″ above the lower border line and producing the centre line of the elevation so as to serve for both views. This plan is taken along the broken line *A B* of the elevation. The purpose of making the line broken is to show two different brick courses of the wall, as seen

JOINERY



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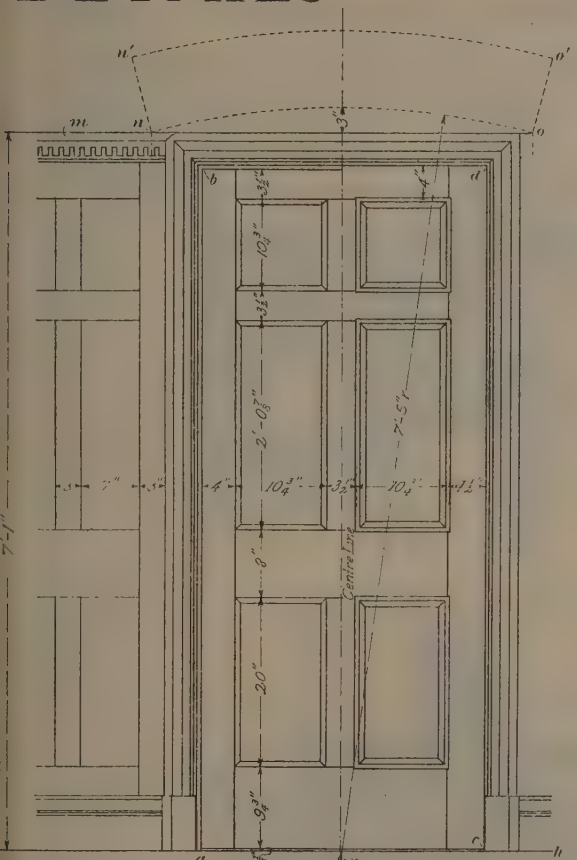
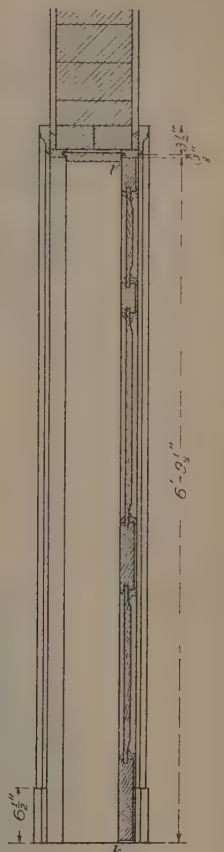
DETAILS

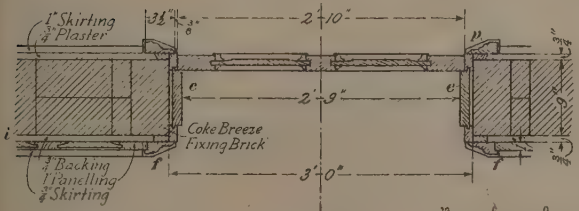


HALL SIDE ——— ROOM SIDE

ELEVATION



SECTION



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PLAN

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by comparing the wall at the left side with that at the right. Complete the plan from the dimensions given, drawing the brick wall first, then the lining, frame, and sashes.

110. Now draw the vertical section of the window, which is a section taken along the centre line of the elevation. The

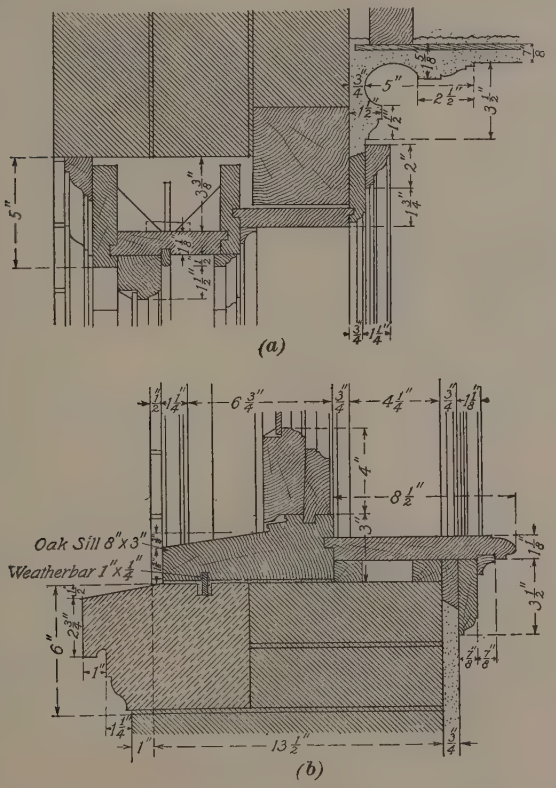


FIG. 38

outside wall line *n o* is to be placed $6\frac{3}{8}$" from the left-hand border line. Draw the brick wall first, projecting the under side of the arch, the wooden filling-in piece *m*, and the stone window sill from the elevation, then draw the window frame and the

sashes. The filling-in piece *m* is $4\frac{1}{2}''$ deep at the centre. Details of the head-lining and the window sill are shown in Fig. 38 (*a*) and (*b*), where additional dimensions may be found. Other dimensions may be taken from the plate *Full-Size Details*.

111. It should be noticed that the vertical section is not placed according to the rules given in *Geometrical Drawing*. The section in this case represents the sectioned part of the window as it will appear when viewed from a position at the right of the window looking toward the left. The view should therefore have been placed to the left of the elevation instead of to the right, where it now is. In architectural drawing this reversal of position is frequently found, because the architect prefers to arrange the views so that similar sides of an object or structure face each other. In this example the left-hand half of the elevation shows the outside of the window. In the section the outside is turned toward the left and adjacent to the elevation. If the section had been placed at the left side of the elevation, the inside of the window would have faced the elevation, which arrangement the architect seeks to avoid, except in cases where he may save room by a different arrangement.

112. The combined internal and external elevation may now be completed by means of the plan and section from which the various details may be obtained by projecting all horizontal lines from the section and all vertical lines from the plan. The distance between the line *c d* on the architrave and the jamb may be found from the plan shown on the plate *Full-Size Details*. The brickwork is set out in 3″ courses, that is, 3″ from centre to centre of joint. In drawing the gauged arch, the sides of the bricks must be radial lines drawn from the centre *h*. To find the width of these bricks, it is necessary to continue the arc *p q* to the left of the centre line. The radius of this arc may be ascertained from the vertical section, where the top of the central brick in the arch is shown at *r*. The arc *p q*, together with the corresponding half on the left of the centre line, should be divided into 19 equal parts and radial lines drawn through the points of division. The top of the lower central brick in the outside arch may also be projected from the vertical

section. A circular arc described from this point will limit the lengths of the other bricks in this arch.

Draw horizontal lines on the outer wall to indicate the brick courses and also a vertical $\frac{3}{8}''$ from the left-hand border line to limit the length of the courses to the left.

113. The drawing of the door may now begin by erecting the centre line of the elevation at a distance of 5″ from the right-hand border line and drawing the floor line *g h* $3\frac{7}{8}''$ above the lower border line. The elevation of the door is also a combination of an internal and external elevation, as shown by the words *Hall Side* and *Room Side* below the elevation.

The inside jamb lines are not the same on both sides of the centre line, that to the right being covered by the door itself. First draw the jamb line *a b* at a distance of $16\frac{1}{2}''$ from the centre line, and the line *c d* corresponding to the edge of the door at 17″ from the centre.

114. Before continuing the drawing of the elevation, draw the plan, placing the outer side of the wall indicated by the line at *i* at a distance of $1\frac{5}{16}''$ above the lower border line. The dimensions given on this plate will, in conjunction with those derived from the plate *Full-Size Details*, suffice for drawing this plan. It will be advisable to draw in first the door linings shown at *e*. These are to be 2′ 9″ apart and their detail can also be obtained from the plate *Full-Size Details*. Observe that the panel mouldings on the room side of the door are raised and lap a little over the edges of the stiles, while the mouldings on the other side of the panels are sunk below the inside face of the door. It will be seen that the profiles of the plinth blocks, as at *f* and *p*, extend beyond those of the architraves.

115. The vertical section, taken through the door panels, may now be begun, drawing a vertical *k l* $1\frac{1}{8}''$ from the right-hand border line. Fig. 39 gives additional details of the capping mould shown at *m* in the elevation. This moulding is ornamented with a series of blocks called *dentils*. The door is drawn first, then the jamb lining with the architraves. Sufficient details have now been drawn in the plan and the section to enable the

elevation to be drawn by projectors from the two views. In order to draw the brick arch over the soffit, it will be necessary to set off the chord $n\ o$ 3′ 9″ long; then, with o as a centre and a radius of 7′ 5″, describe a short arc across the centre line, thus fixing the centre p. From this centre the arcs $n\ o$ and $n'\ o'$ may now be described. Only the outline of this arch is indicated. The top edge of the door may now be drawn a distance of 6′ $9\frac{1}{8}$″ above the floor line $g\ h$; then draw the door panelling and the jamb lining by projecting the various parts from the plan and the section.

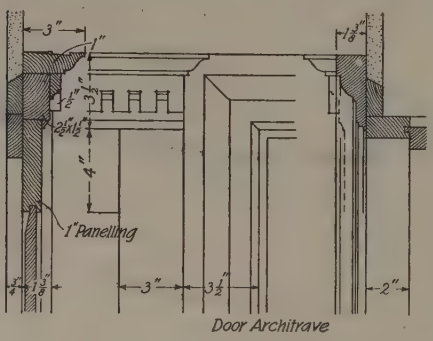
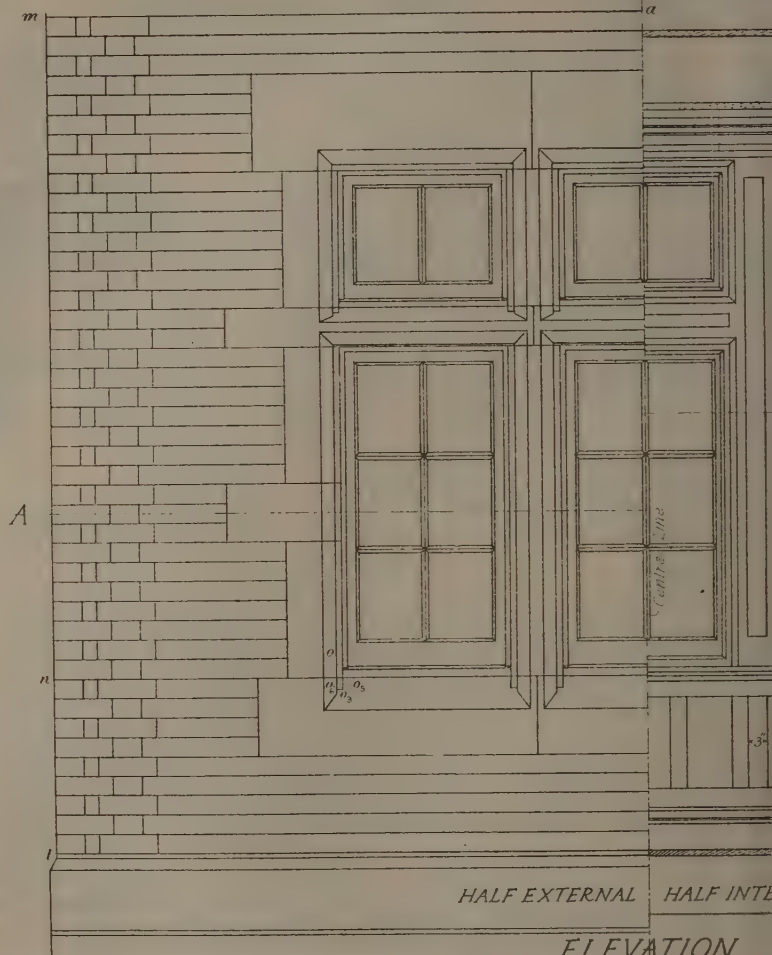


Fig. 39

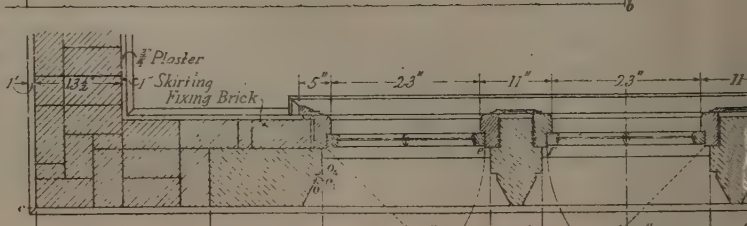
116. Detail dimensions of the capping m are found in Fig. 39. The profile of this capping would also be visible at the architrave in the section, but by reason of its smallness it is not customary to show it, and it has therefore been omitted from the plate. The positions of the rails in the panelling at the left of the door in the elevation correspond in position with those in the door.

This plate is not to be inked in, but a tracing is to be made in ink on tracing cloth from the finished pencil drawing. On this tracing is to be inserted the section lining, shown on the original drawing plate. The style of the section lines ordinarily used to represent wood cut across the grain is shown in the plans and sections on this plate, and should be studied carefully. The section lines used to indicate plaster, stone, and brickwork are according to the section lining shown in Fig. 31. The reference letters should be omitted from the finished tracing. Guide lines for the title, when made on the pencil drawing, should be drawn at distances of $\frac{1}{4}$″ and $\frac{3}{4}$″ below the upper border line. It is not necessary to forward the pencil drawing for examination, but only the tracing.

DETAIL O



ELEVATION



PLAN ON LINE A–

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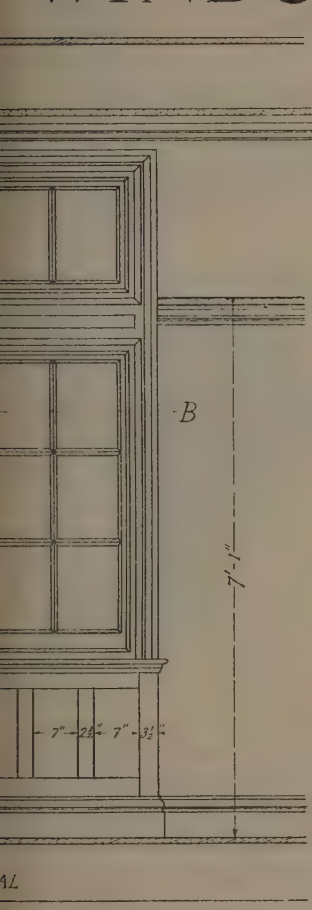
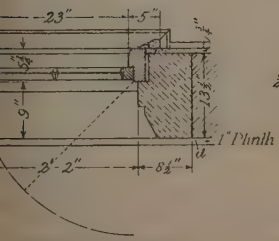
WINDOW





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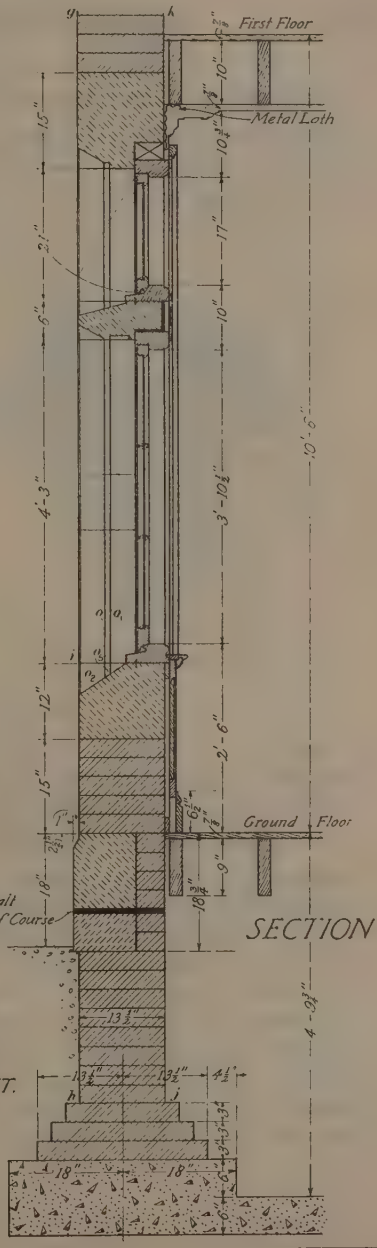

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DRAWING PLATE, TITLE: DETAIL OF WINDOW

117. This plate gives the construction of the mullion window situated in the morning-room on the ground floor of the two-story building. It is shown on the plate in elevation, plan,

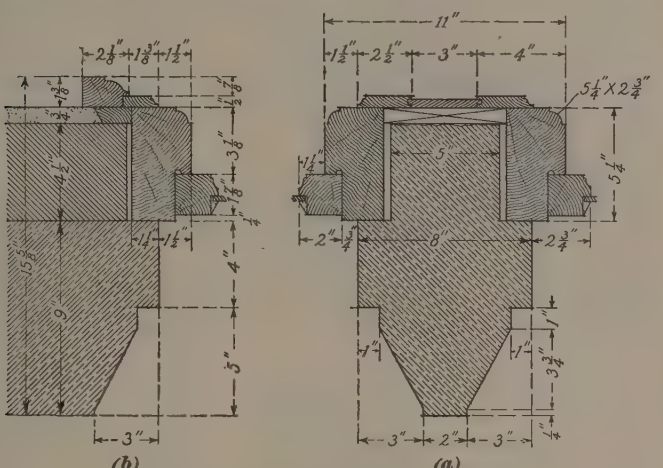


FIG. 40

and section, all drawn to a scale of $\frac{3}{4}'' = 1$ ft. Details of the jamb, mullion, sill, and transom are shown in Figs. 40 and 41. The window is constructed in a brick wall, the exterior being finished with stone dressings.

118. Begin the plate by drawing the centre line of the elevation, at a distance of 7″ from the left-hand border line, extending it so as also to serve for the plan. The plan, which is a horizontal section along the broken line *A B* of the elevation, may be completed first; the outer face line *c d* of the wall is placed at a distance of $1\frac{1}{16}''$ above the lower border line. The window, as shown in the plan, is arranged on both sides of the extended centre line *a b*. Set off first the inner sides of the stone mullions at distances of 13″ from the centre line; make each mullion 8″ wide and $13\frac{1}{2}''$ deep, and complete the outline from the

dimensions given in Fig. 40 (*a*). Then set off the stone jambs, using the data given in Fig. 40 (*b*). An imaginary line *e f* that would pass through the outer corners of rabbets for the wooden frames is 9″ inside of the mullion face. Line *e f* should be produced so as to serve for all the jambs in the window, and from this line all the details of the window frame should be set out according to the dimensions found in Fig. 40. Add the remaining details of the window and complete the corner of the brick wall at *c*, making the wall $13\frac{1}{2}$″ thick.

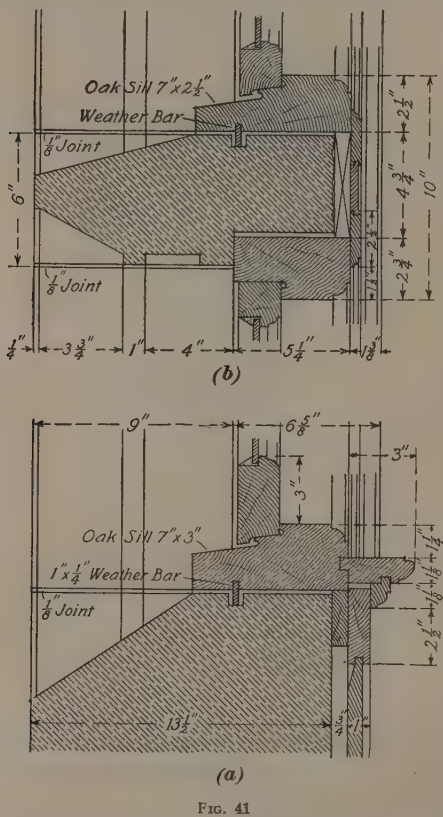


Fig. 41

119. Set off a space of $\frac{3}{4}$″ for the plaster and 1″ for the skirting; also draw the window board extending $3\frac{3}{4}$″ beyond the inside of the wall. The circular arcs with radii in dotted lines, shown outside the sashes, indicate that the latter open outwards and show also on which side the hinges are fixed. Draw lines parallel to the outer faces of the walls, at distances of 1″, to indicate the outside of the plinth course.

120. The vertical section is taken along the centre line of the elevation. For the reason already given in Art. **111**, the outside

of the wall in this section is placed so as to face the elevation. Place the line *g h* representing the wall face $3\frac{5}{8}''$ from the right-hand border line, and draw a line parallel to it and at a distance of $13\frac{1}{2}''$ to represent the inside of the wall. Fix a point *i* $5\frac{1}{16}''$ above the lower border line and draw a horizontal through this point to indicate the top of the window sill. Draw other horizontals to represent the top and bottom of the plinth course, and 2′ 0″ below the latter draw *h j* as the top of the footings. Bisect *h j* and through its centre draw a centre line; then draw the footing courses symmetrical to this line. Finally, add the concrete foundation.

121. Before proceeding with the vertical section, it is preferable to draw part of the elevation and to use this as an aid in drawing the section. For this purpose draw the vertical *l m*, its position being found by a projector from the plan, and project point *i* from the vertical section to *n* on *l m*; also the top line of the plinth course and the ground line *o b*, which, as seen from the vertical section, is 18″ below this line. Divide the line *l m* on both sides of point *n* into equal spaces, each representing the thickness of a brick course, in this case 3″. Through these points of division draw short horizontals of indefinite lengths. As all the vertical dimensions in the vertical section are multiples of a brick course, they may easily be set off by projecting from *l m* the required number of courses. By following this method, it will also be much easier in drawing the elevation to insert the stones in the jamb, the sill, and the lintel, and so ensure that their upper and lower sides coincide with a brick course.

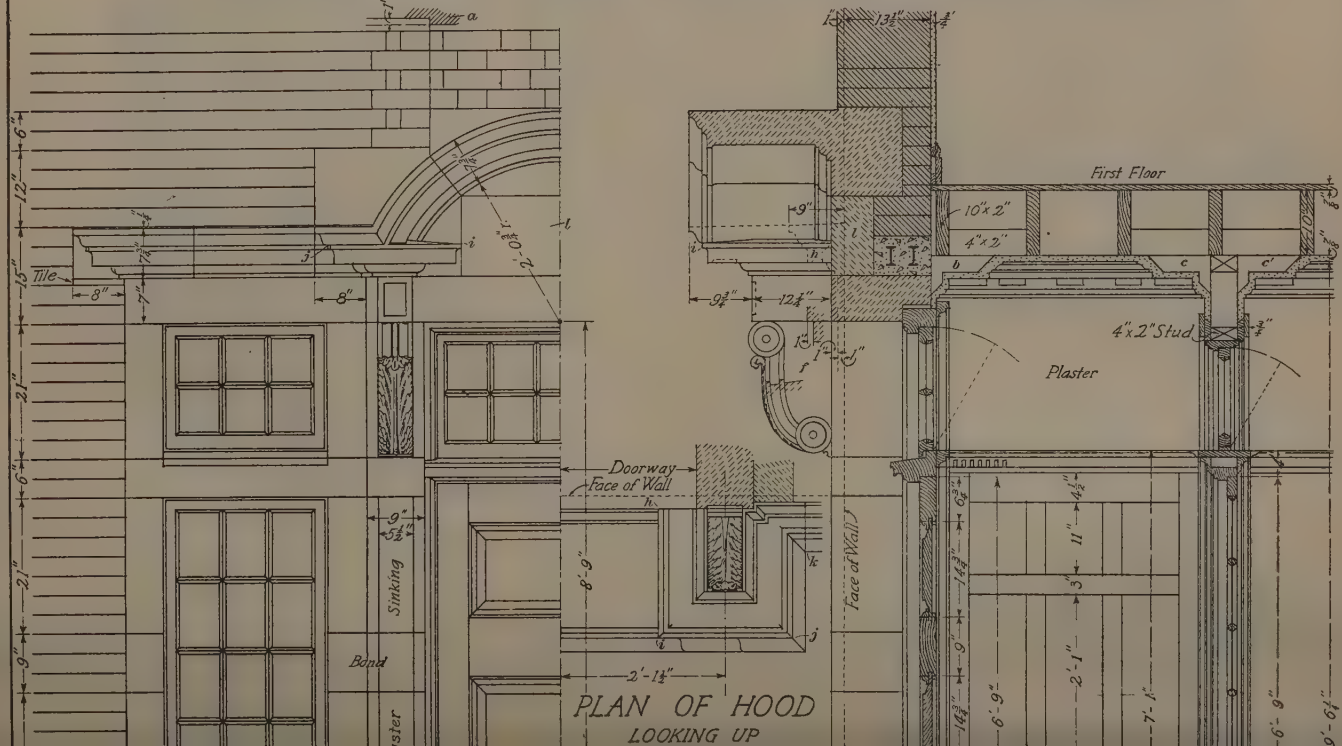
122. Continuing the drawing of the vertical section, project from the elevation the number of courses necessary to give the required thickness of the stones in the sill, the transom, and the lintel. Show the complete sections of these stones and indicate the brick courses in the section. Draw the wooden sill and transom from the dimensions given in the detail views, Fig. 41, where also other details of the window frame and sashes are shown. The two floors with their floor joists should now be added, also the plastered ceiling of the ground floor. Add the architrave and the panelling with the skirting and other details.

123. Proceeding with the drawing of the elevation, observe that it shows half the external and internal elevations of the window, the views adjoining at the centre line. Begin with the half of the external elevation at the left of the centre line and project from the plan the length of the transom and the long jamb stone through which the section line $A\ B$ passes. The sill and lintel are one-half of a brick shorter than these ; insert the mullion. In drawing the chamfers on the angles of the jamb and mullion, particular care is required to see that the intersection of this chamfer with the sill is correctly outlined. If the point of intersection between the projectors from the vertical section and the plan is correctly placed, there should be no difficulty. For instance, the corners o, o_1 in the plan are represented in the vertical section by the verticals at o and o_1, but in the elevation only by the vertical at o. To find the position of point o_3 in the elevation, it will be necessary to project from the vertical section the point o_2. The point of intersection between its projector and the line at o will be the required point o_3. Similarly, the line $o_1\ o_4$ in the plan corresponds with the line $o_6\ o_5$ in the elevation, but the position of this line can be found only by projecting the point o_5 from the vertical section to the line at o. A line $o_6\ o_5$ through the point of intersection o_6 gives the position required. In a similar manner, other points are found on the chamfered corners.

124. The wooden sills, soffits, and jambs may now be drawn by projecting the required dimensions from the plan and section ; then the window sashes may be drawn. Proceeding to draw the interior half of the elevation, the interior finishings may be drawn by using the detail dimensions found in Figs. 40 and 41. The two floors with the joists are next drawn, also the plastered ceiling and the skirting at the ground floor. Finally, draw the panelling under the window board with the stiles spaced, as indicated. Draw the parallel lines for the title at distances of $\frac{1}{8}''$ and $\frac{5}{8}''$ below the upper border line. This plate is to be finished in pencil only and a tracing made from it in the same manner as the preceding plate ; only the tracing is to be forwarded for examination.

DRAFT OF MAY 1

DETAIL OF ENTRANCE



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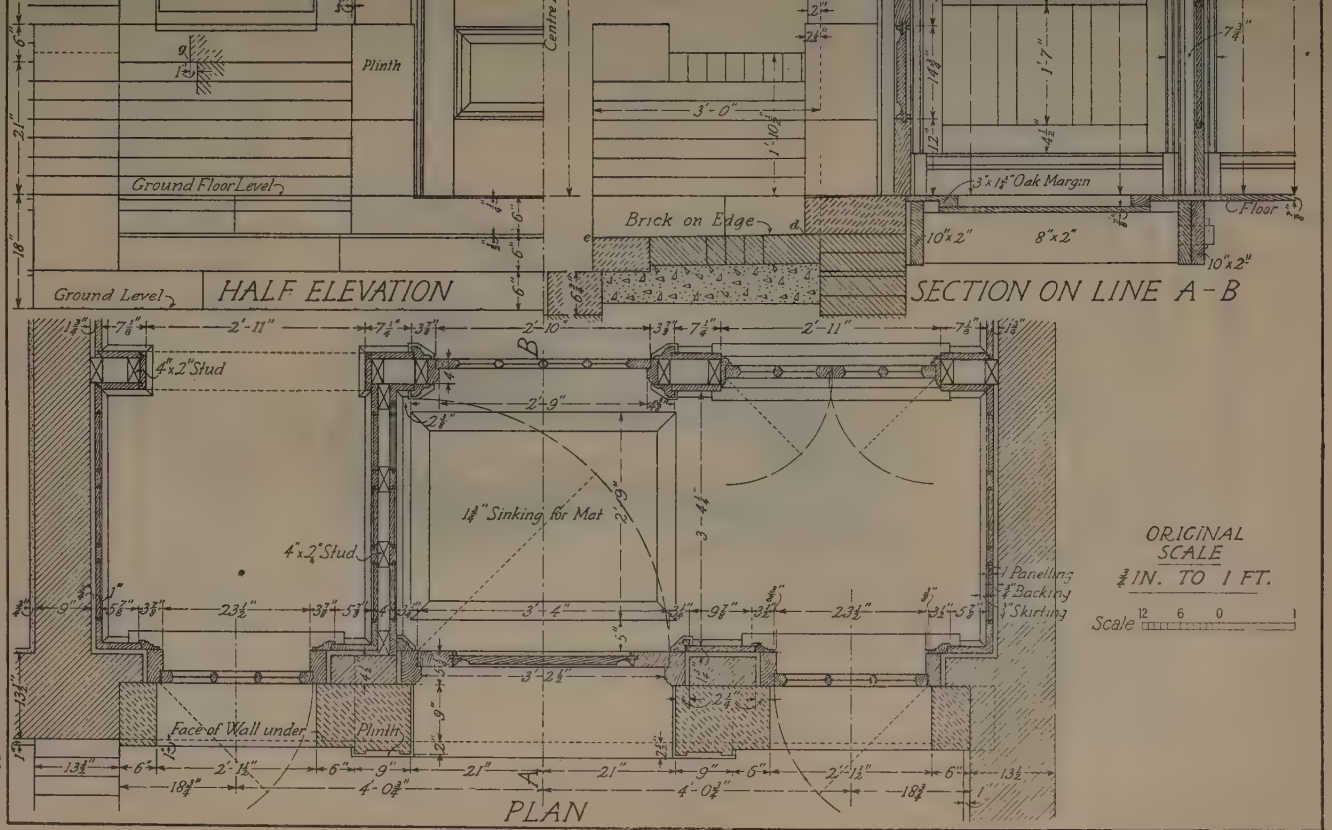


DRAWING PLATE, TITLE: DETAIL OF ENTRANCE

125. This plate shows the detail drawings for the vestibule at the front entrance door illustrated in perspective in Fig. 42. The views given are: One half-elevation of the vestibule exterior, a plan, a vertical section, and a part plan of the hood, as it appears when viewed from below. They are all drawn to a scale of $\frac{3}{4}'' = 1$ ft.

FIG. 42

126. The entrance doorway is constructed in a brick wall with stone pilasters at the door, supporting stone brackets with cornice and hood. At each side of the door there is a window with a fanlight; above the door is also a fanlight. From the vestibule a door opens into the front hall, and at the right side of this door there is a window opening from the hall into the

vestibule ; this window is shown only in the plan. At the left of the vestibule there is a small alcove suitable for keeping hats and coats. In order that the full width of the vestibule may be utilized, the entrance door swings to the left into a recess, as indicated by the arc in dotted lines. The interior door is fitted with glass panels and also swings inwards. In front of the entrance there is a porch with brick paving, two stone steps, and a dwarf wall to the left.

127. Commence the plan by drawing a horizontal line to represent the face of the wall at a distance of $\frac{3}{16}''$ above the lower border line, also the main centre line for the plan and elevation $5\frac{5}{16}''$ from the left-hand border line. Draw the ground-floor level for the elevation and section at a distance of $6\frac{1}{4}''$ above the lower border line. Set off the thickness of $13\frac{1}{2}''$ for the front wall in the plan and mark the positions of the centre lines for the two windows ; then begin to draw the openings for the door and windows, marking off from the centre line in each case the dimensions of those parts that are symmetrically arranged on each side of it. Also draw the side walls, as indicated, extending them for a distance of 5″ from the lower border line.

128. With architectural drawings of the kind shown on this plate, it is inconvenient to finish one view independently of the others ; they must therefore be drawn jointly, that is, similar details in the separate views should be completed before the drawing of other parts is begun. It is therefore necessary to fix at once the position of the section by placing the line indicating the face of the wall $4\frac{15}{16}''$ from the right-hand border line. The outside and inside of the brick wall may now be indicated by vertical lines $13\frac{1}{2}''$ apart. Observe that the part of the brick wall situated above the hood projects 1″ beyond the main wall ; this is indicated by the small section shown at *a* above the elevation. The face of the stone pilaster projects a distance of 2″ beyond the main wall and the two plinth courses $\frac{1}{2}''$ farther.

129. To facilitate the setting out of the correct thickness of the stones in the pilaster, it is necessary to mark off on the

elevation the thickness and number of the brick courses included in the elevation. For this purpose it is necessary to draw a vertical line in the elevation at a distance of $1\frac{3}{16}''$ from the left-hand border line and to set off on this vertical a number of divisions 3″ apart; then draw short horizontal lines through the points of division.

The stone pilaster may now be indicated in the section, making the height of each separate stone equal to a whole number of brick courses, as shown in the elevation. These parts should also be drawn in the plan and finally in the elevation by projectors from the plan and the section.

130. A plan of the hood, looking up, is shown between the elevation and the vertical section. Draw the dotted line indicating the face of the brick wall $5\frac{7}{8}''$ below the top border line, and the centre line for the bracket at the distance from the centre line indicated on the plate. Observe that in this view the section through the pilaster does not correspond with that in the plan. In the latter view the section is taken through the bond stone in the pilaster, but in the plan of the hood the section is through the pilaster and the jamb of the adjoining window.

131. To draw the hood, beginning should be made with the elevation, the centre of the hood being set off 8′ 9″ above the ground-floor level. From this centre describe the outer and inner arcs of the hood. Detail dimensions of the moulding on the hood and cornice have not been given, but it should be noted that the profile on the front sides of the cornice and the hood should be the same.

It requires some careful comparison of the three views in order that the shape of the cornice may be fully understood. For instance, the plan looking up shows that above the pilaster the cornice has a projecting part *h i j k*. At *k* this part joins the part of the cornice that extends over the window. In the elevation this projecting part of the cornice is indicated by the letters *i j*, and in the section by letters *h i*. In the section is shown at *f* on the bracket a small section to indicate that the surface on the main body of the bracket is sunk for a distance of 1″ below the moulded front part.

Similar detail sections are added to a view when it is necessary to indicate that of two surfaces shown in elevation, one projects beyond the other. Another example of similar sections is found in the elevation at *g* on the window sill. Here it is intended to show that the sill projects 1″ beyond the face of the brick wall.

132. Particular attention should be paid to the mouldings on the cornice, the hood, and the brackets, so that the corners and recesses may be indicated correctly. It is not necessary to indicate the ornament on the bracket with the same amount of detail as is shown on the plate ; a few of the main lines will suffice, or they may be omitted entirely

133. It is not always convenient or desirable that the height dimension of each separate stone in the facing of the windows and doors should be an exact multiple of the height of a brick course. An example of this kind is found in the stone lintel above the windows and the door. To correspond with the height of two brick courses it should be 6″ thick, but as this would make it appear rather low, it has been increased to 7″. The result is that between the under side of the cornice and the adjoining brick course there is a space of 1″. In the elevation the word *Tile* indicates that this space has been filled with tiles. In the section there is shown above the stone lintel a concrete lintel reinforced with two steel **I** joists, its purpose being to relieve the lintel from any central load. The concrete lintel is behind a stone fascia *l*, which is shown in the section and the elevation.

134. The porch with the dwarf wall may now be drawn. In the elevation the outlines of these parts coincide so nearly with the main wall that they cannot be seen very well ; but the section gives a side elevation of the dwarf wall and a section through the brick paving and the stone steps. Notice that the brick floor is weathered so that the point *c* is $\frac{1}{2}$″ lower than *d*. The amount of weathering is indicated in the elevation by two horizontal lines $\frac{1}{2}$″ apart. The porch in the vertical section should be drawn first, then it may be added to the plan and elevation.

135. The woodwork may now be drawn, beginning with the main door in the plan. A detail section of the door jamb for this and the hall door is shown in Fig. 43, where also the vestibule panelling, as well as the adjoining window jamb, are shown, the central part of the panelling being cut away. Set off the

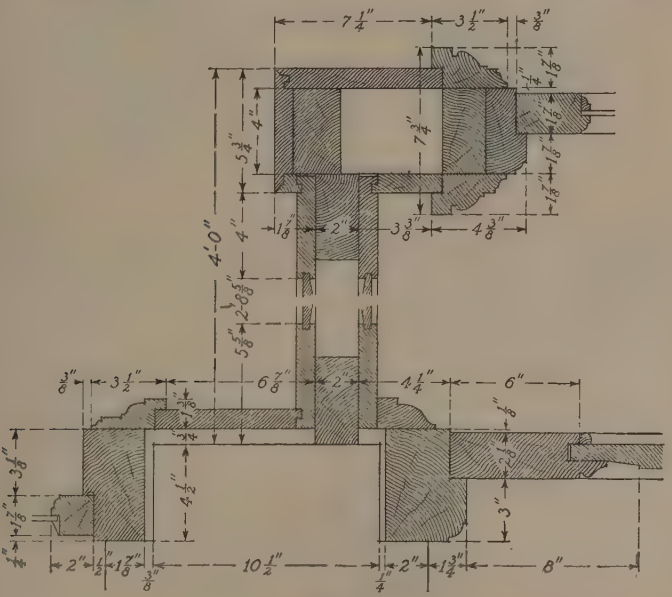


Fig. 43

dimensions of the doors and window on both sides of their respective centre lines, also the door and window jambs. Draw the wall panelling 1″ thick and at a distance of $\frac{3}{4}$″ from the wall ; add the supporting studs and the skirting.

136. In the floor of the vestibule there is $1\frac{3}{4}$″ sinking, with a 3″ × $1\frac{3}{4}$″ oak margin, for a door mat. A cross-section of the sinking is shown in the vertical section, which also shows that the bottom is supported by 8″ × 2″ joists. The first floor with the 10″ × 2″ joists may now be drawn.

Fig. 44 (*a*) and (*b*) gives detail dimensions of the external and internal fanlights, respectively. After these parts have been

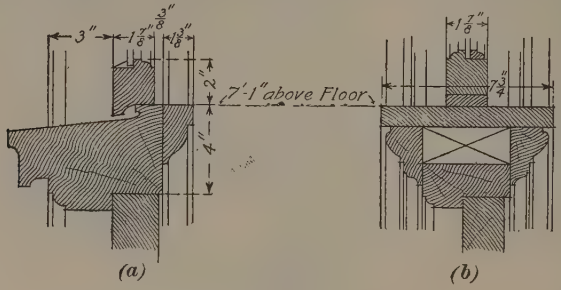


Fig. 44

drawn, proceed to add the plastered ceiling. In Fig. 45 is shown the details of the plastered cornice for the ceiling in the vestibule and the adjoining hall. As seen from this view, the laths are nailed to rough brackets *c* and *c'*. These brackets are also shown in the vertical section on the plate, where, also, another bracket *b* is seen near the outer wall. The ceiling cornice is ornamented with a series of 6″ × 4″ blocks. Two of these blocks are shown in side elevation below the brackets *c*, *c'*, Fig. 45.

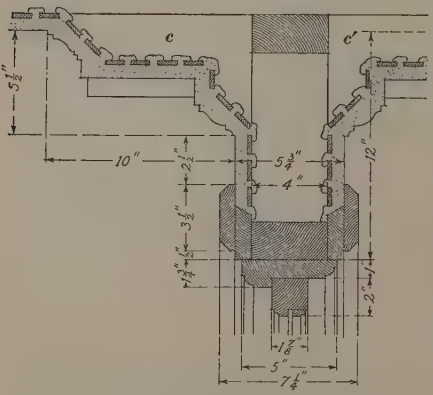
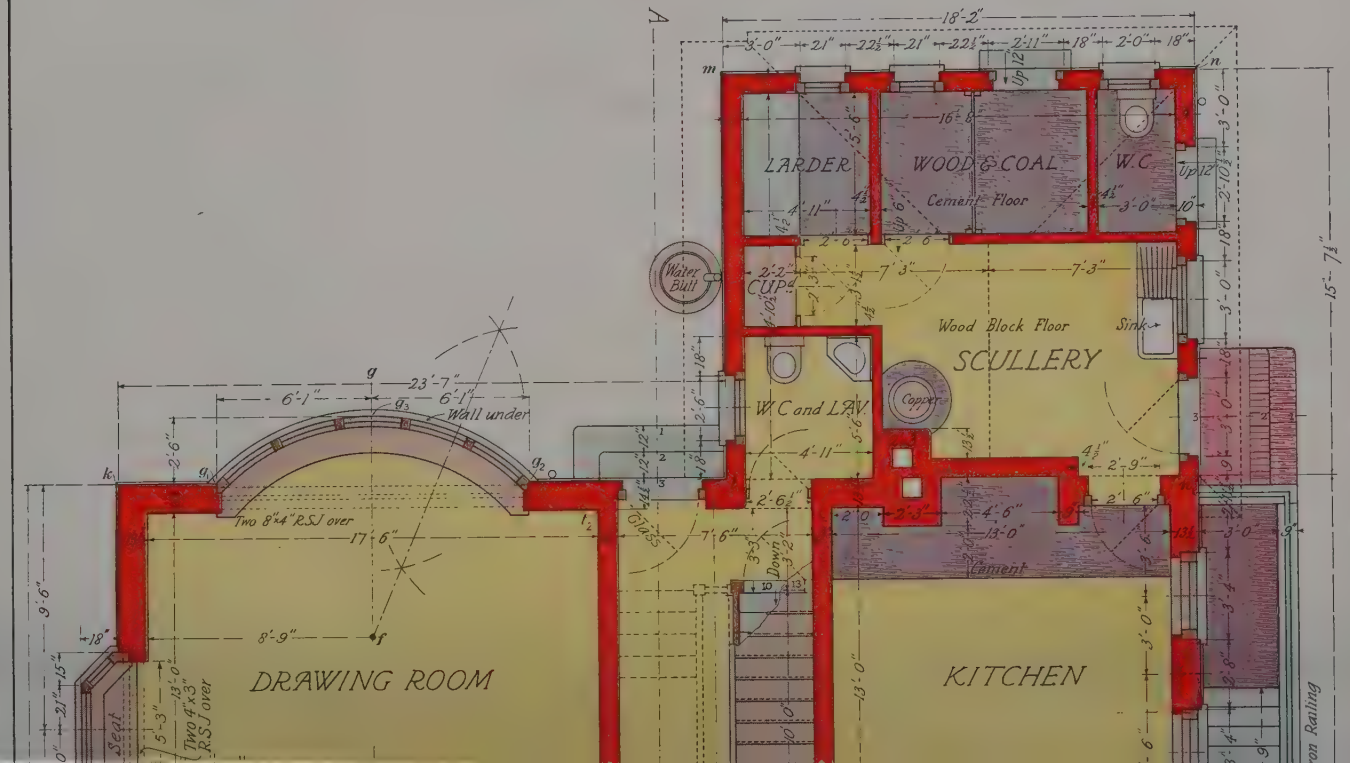


Fig. 45

In the finished drawing the reference letters found on the plate should be omitted. For the insertion of the main title, draw two horizontal lines at distances of ½″ and 1″ from the upper border line. This drawing plate is to be inked in and section-lined in the same manner as the original drawing plate.

GROUND-FLOOR PLAN



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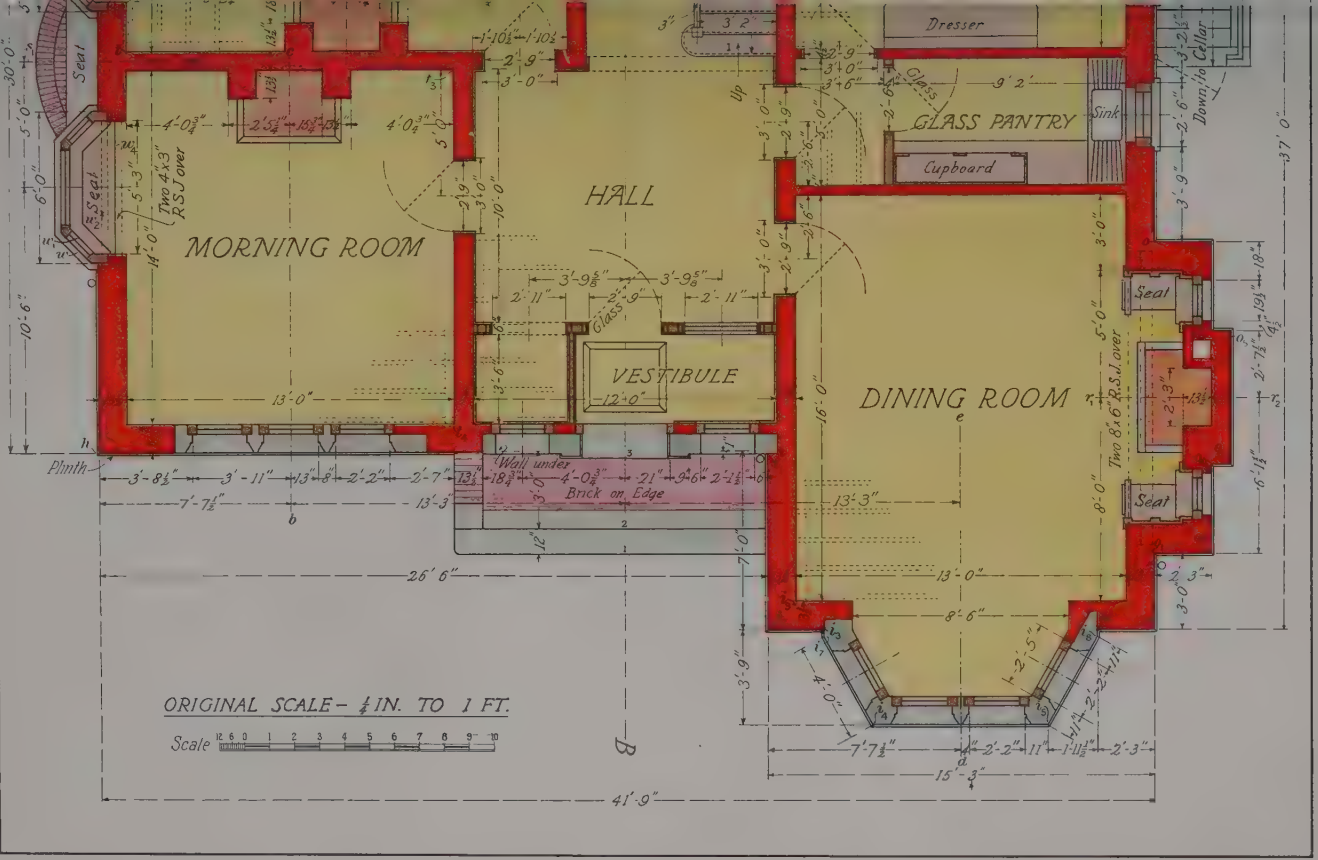

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DRAWING PLATE, TITLE: GROUND-FLOOR PLAN

137. In practice, the architect works out the general scheme for his plans by means of some small sketches, similar to those

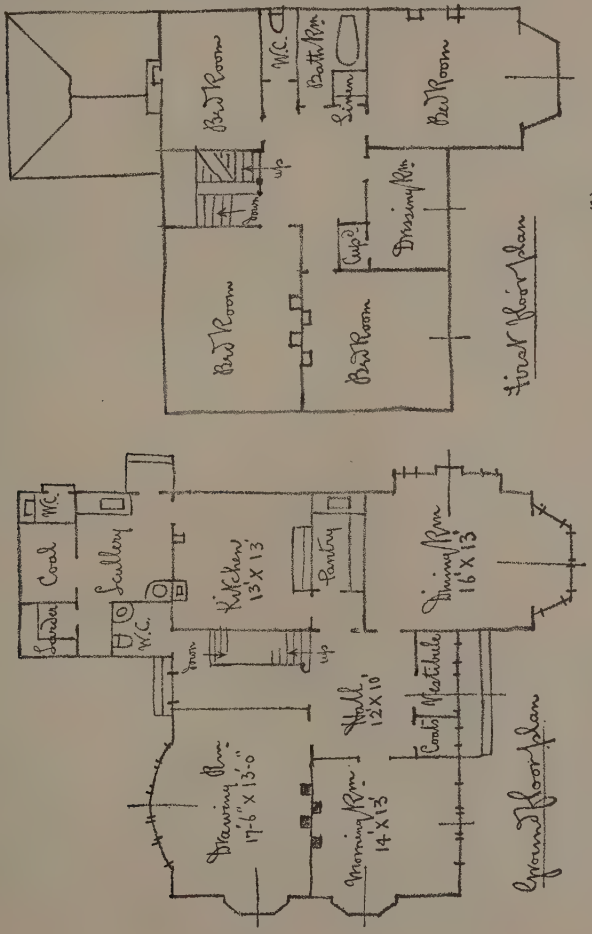


Fig. 46

shown in Fig. 46, in which view (*a*) represents the ground-floor plan, and (*b*) the first-floor plan. On these sketches he marks the sizes of the rooms and the name of each. If they are satisfactory, and the architect is sure that the room partitions and other details will come just where intended, then the draughtsman can proceed with the ground-floor plan.

138. Before beginning the plan proper, it is first necessary to select some convenient centre lines and wall lines from which the more important dimensions may be set off. As the main centre line of the plan the section line *A B* may be used. Draw this line at a distance of $6\frac{1}{4}''$ from and parallel to the left-hand border line ; then draw the horizontal line *h i* to represent the outside of the front wall 4″ above the lower border line. To find the positions of the exterior angles of the building, which are all right angles, proceed as follows : Set off on line *h i*, from centre line *A B*, a distance of 20′ $10\frac{1}{2}''$, thus fixing the position of angle *h*. Measuring a length of 26′ 6″ from *h* along *h i* fixes the position of angle i_1. Draw the face line $i_1\ i_2$ 7′ 0″ long and another face line $i_2\ p$ 15′ 3″ long. From *p* draw a vertical of indefinite length to define the face line of the side wall. Returning to the angle *h*, draw the face line *h k* and set off *k* at a distance of 30′ 0″ from *h*. After drawing the horizontal line *k l*, fix the point *l* at a distance of 23′ 7″ from *k* and draw the face line *l m* 15′ $7\frac{1}{2}''$ long, then draw *m n*. Produce line *k l* so as to intersect line *p n* at n_1.

139. The angles defining the main outline of the building being fixed, proceed to establish the face lines of the bay window in the dining-room and also those of the recessed fireplace, or inglenook. Draw the centre line *d e* of the bay window at a distance of 13′ 3″ from line *A B*, then draw the line $i_4\ i_5$ parallel to $i_2\ p$ and fix points i_4 and i_5, each at a distance of 3′ 5″ from *d e*. Set off from points i_2 and *p* a distance of 2′ 3″, fixing the positions of the angles i_3 and i_6. Through the latter two points draw short verticals, and, using points i_4, i_5 as centres, describe short arcs with radii of 4′ 0″ intersecting the verticals at i_7 and i_8, by this means fixing the positions of angles i_7 and i_8.

140. To draw the inglenook, set off the point o_1 at a distance of 3′ 0″ from p and make the side $o_1\ o_2$ 2′ 3″ long. Draw $o_2\ o_7$ of indefinite length and set off on it from o_2 two points 6′ $1\frac{1}{2}$″ apart; through the first point draw the centre line $r_1\ r_2$ and through the second point the line $o_7\ o$. Fix points $o_4\ o_6$ at a distance of 2′ $7\frac{1}{2}$″ from $r_1\ r_2$ and draw $o_3\ o_5$ parallel to $o_2\ o_7$ at a distance of 9″, then complete the angles o_3 and o_5.

141. To establish the face lines of the bay windows in the morning- and drawing-rooms, set off the centre line $s_1\ s_2$ for the wall between these rooms at a distance of 15′ 6″ from the angle h; at a distance of 5′ 0″ on each side of this centre line set off the centre lines for the bay windows. Make the total width of each window 6′ 0″ and let the outer face project 18″ beyond the wall face. Detail dimensions for these windows and the intervening stone seat are found on the plan in Fig. 47. The curved edge of the brick pavement under the stone seat is described with a radius of 6′ 3″; the outer edge of the seat is 15″ from the wall face.

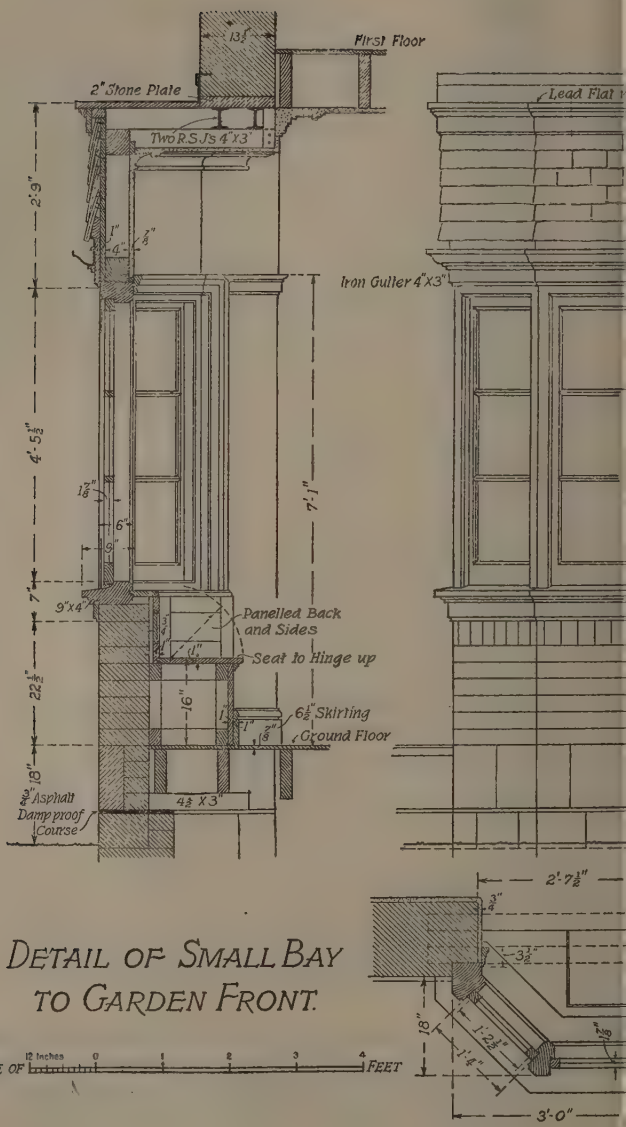
142. The bay window at the rear of the drawing-room has a centre line which is at a distance of 9′ $10\frac{1}{2}$″ from the face of the left-hand wall. Set off on both sides of this centre line along the wall-face line distances of 6′ 1″ to determine the positions of points g_1 and g_2. Also set off along the centre line a distance of 2′ 6″ from the face of the wall so as to fix point g_3. By means of the chord $g_2\ g_3$, find in the usual manner the centre of the arc $g_1\ g_3\ g_2$ and then describe the latter.

143. The thickness of the brick wall being indicated as $13\frac{1}{2}$″, the inner face lines of the walls may now be drawn, beginning by describing with the compass a quadrant with a radius of $13\frac{1}{2}$″ at the angles h, i_1, i_2, p, and n_1, taking the vertex of each angle as the centre. Tangent to these arcs and parallel to the face lines, draw the inner face lines of the walls. The points of intersection of these lines will define the interior angles. To obtain the jamb line of the bay window at centre line $d\ e$ set off at both sides of this line along the outer face line $i_2\ p$ a distance of 4′ 3″; verticals drawn through these points will give the jamb line that intersects the side wall of the window.

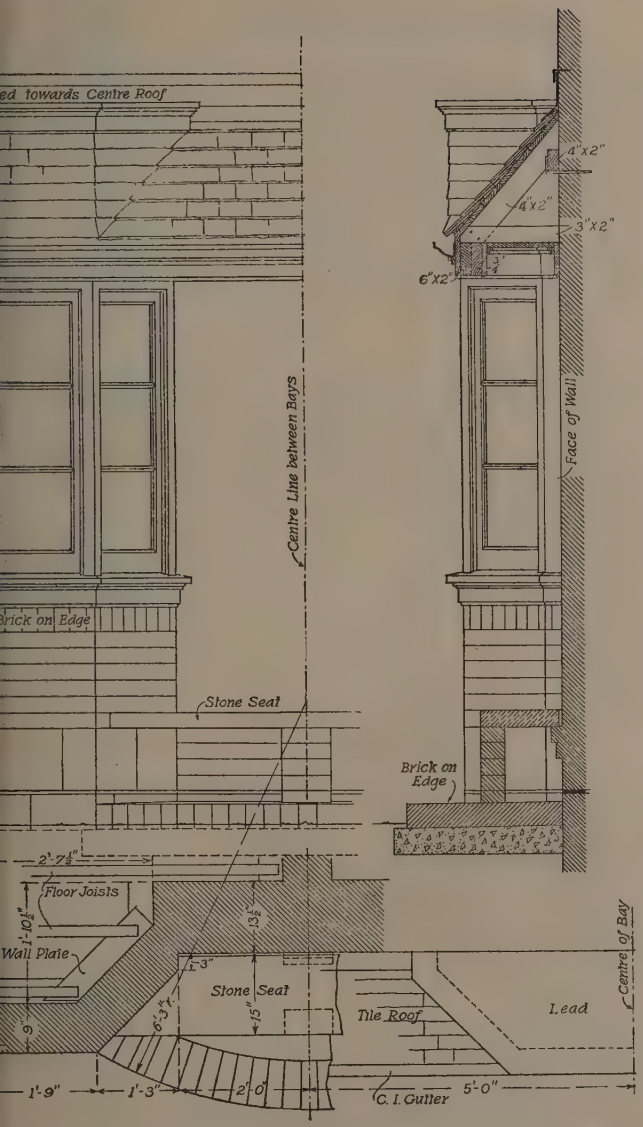
144. The plans of the bay windows in the morning- and drawing-rooms are indicated in general outlines only and show the woodwork without the sashes. Leave a space of 6″ between outside and inside lines, as w and w_1. Lines w_2 represent the window board and a space of 5″ is left between w_1 and w_2. The line w_4 represents the inside edge of the window seat and is a distance of about 9″ inside the face line of the outside wall, but the details of these parts are not required to be accurate in this plan. The outside stone seat with the brick paving may now be added. The dimensions and positions of any part that are not given on the plan may be ascertained by means of the scale given on the plan.

145. Proceeding to draw the inner walls or partitions, produce the centre line $s_1\ s_2$ so as to extend across the plan. Set off on each side of this line $4\frac{1}{2}$″ and draw the face lines of the wall parallel to the centre line. The length of this wall is 17′ 6″; therefore, set off this length on the face $t\ t_1$ and through t_1 draw the vertical $t_1\ t_2$ and draw a line parallel to it at a distance of 9″ for the other face of the wall. Draw the face line $t_3\ t_4$ of the wall for the morning-room and make the walls 9″ thick. No door or other opening should be shown in these walls until the latter are all drawn. Extend the face line of the dining-room from angle i_9 so as to intersect the face line $k\ n_1$; this wall is also 9″ thick. The wall extending from the angle l to point n_1 should have a thickness of $13\frac{1}{2}$″ and may be considered as an extension of the rear wall of the drawing-room. By extending the face line $t\ t_1$ across the plan, it will serve as the face line for the wall between the kitchen and the glass pantry. This wall and the opposite one are both $4\frac{1}{2}$″ thick, the distance between them being 5′ 0″. The short partition at the entry of this pantry has a thickness of 4″ and is placed at a distance of 3′ 6″ from the hall wall.

146. Now draw the outer face line of the partition between vestibule and hall 3′ 6″ from the front wall; make this partition 6″ thick. Also draw the vestibule partition 3′ $8\frac{3}{4}$″ from the morning-room wall and make it 4″ thick. Draw a face line for the wall between the scullery and the wood and coal cellar



DETAIL OF SMALL BAY TO GARDEN FRONT.


ed towards Centre Roof
4"x2"
4"x2"
3"x2"
6"x2"
3/4
Face of Wall
Centre Line between Bays
Brick on Edge
Stone Seat
Brick on Edge
2'-7½"
Floor Joists
1'-10½"
Wall Plate
13½"
1'-3"
Stone Seat
15"
6'-3"
9"
Tile Roof
Lead
Centre of Bay
1'-9"
1'-3"
2'-0"
C. I. Gutter
5'-0"

at a distance of 5′ 6″ from the rear wall and make this wall $4\frac{1}{2}$″ thick. Then set off from the left wall at a distance of 4′ 11″ a wall for the larder, making it $4\frac{1}{2}$″ thick. Place a wall of the same thickness at the other end of the wood cellar at a distance of 3′ 0″ from the outer wall. Indicate a wooden partition for the coal bin at a distance of 3′ 6″ from the larder wall. Finally, draw one of the walls for the *W.C. and Lav.* parallel to the face line $l\,n_1$ and at a distance of 5′ 6″ from it. At right angles to this draw the other wall 4′ 11″ from the outside wall. Both of these walls are $4\frac{1}{2}$″ thick.

147. The fireplace opening in the rear kitchen wall for the kitchen stove may now be drawn, using the face line $l\,n_1$ as one face line of the recess and the other 9″ to the rear of it. Insert the outline of the chimney breast according to the dimensions given. The dimensions indicating the positions and sizes of the flues are not given, but are easily found, as they necessarily depend on the dimensions of a brick; the chimney walls will therefore vary in thickness between $4\frac{1}{2}$″, 9″, and $13\frac{1}{2}$″.

The centre lines of the fireplaces in the morning- and dining-rooms coincide with the respective centre lines of these rooms. The fireplaces can easily be set out from the dimensions given on the plate. Draw, also, the outlines of the hearths, taking sizes with the dividers, which, if applied to the scale at the lower edge of the plate, will give the dimensions.

148. The outlines of the walls and partitions are now finished and the door openings may therefore be indicated; where their centre lines are indicated the measurement should be made from them. Otherwise, find their positions from the nearest angle of the room. On the plate, the distance of the centre line from the adjoining angle of the room is given in most cases. The centre lines of the two doors in the vestibule coincide with the centre line of the hall; therefore, for the main door, set off 21″ on each side of this line. For the inner door measure off $16\frac{1}{2}$″ on each side of the centre line. The door at the angle l opening from the garden into the hall has an opening 3′ 2″ wide, the distance between its jamb and the adjacent angle l is $11\frac{1}{4}$″. The positions of the other door openings are so clearly shown that

no further instruction is required. After the openings for the doors are placed, draw in the arcs with dotted lines, as shown, defining the edge at which the door is hung, and draw a dotted line at an angle of 45° to the wall denoting the open door.

149. The staircase may now be drawn, beginning with the centre line of the straight portion of the hand rail of the first flight, shown in full lines. The centre line of this rail is 3′ 2″ from and parallel to the face line of the wall. Set off the centre line of the rail of the return flight at the same distance from the other wall. These rails, together with the strings, form what is termed the *well* of the staircase. Before the position of the stairs and the dimensions of the treads and risers can be set off, it is necessary to make a special elevation of the stairs showing the positions of the two floor levels, and by this means to ascertain the required dimensions of the risers and treads with the resulting inclination of the stairs.

150. In Fig. 48 is shown a section through the rear wall and the positions of the three floor levels. In the present case the height from the ground floor to the first floor is 10′ 6″, and if a rise of 7″ is allowed for each stair, there will be $126 \div 7 = 18$ risers in all. The space between the two floors will therefore have to be divided into 18 equal spaces. The easiest manner in which this may be done is by laying a scale diagonally across the space, as indicated by the line $A\,B$, Fig. 48. Selecting any convenient subdivisions, such as the $\frac{1}{2}$″ marks, the line $A\,B$ would be 9″ long. A pencil mark is made in front of each $\frac{1}{2}$″ mark on the scale, as shown on the illustration.

151. The first half-landing is arranged at such a level as to allow sufficient headroom for the garden entrance on the ground floor. It is therefore fixed at the level of the thirteenth tread and is 7′ 7″ from the ground floor. As the landing is given a width of 3′ 2″ and a width of tread of 10″ is adopted, the position of the first riser will necessarily be $12 \times 10'' + 3'\,2'' = 13'\,2''$ from the rear wall. A line $D\,C$ is drawn from the top of the first riser to the half-landing, and horizontal lines are drawn from the points of division on $A\,B$ toward $C\,D$. The points of intersection

with the latter will fix the positions of the intermediate risers. In order to find point b where the eighteenth riser intersects the first-floor level, set off from point a a distance of $4 \times 10''$

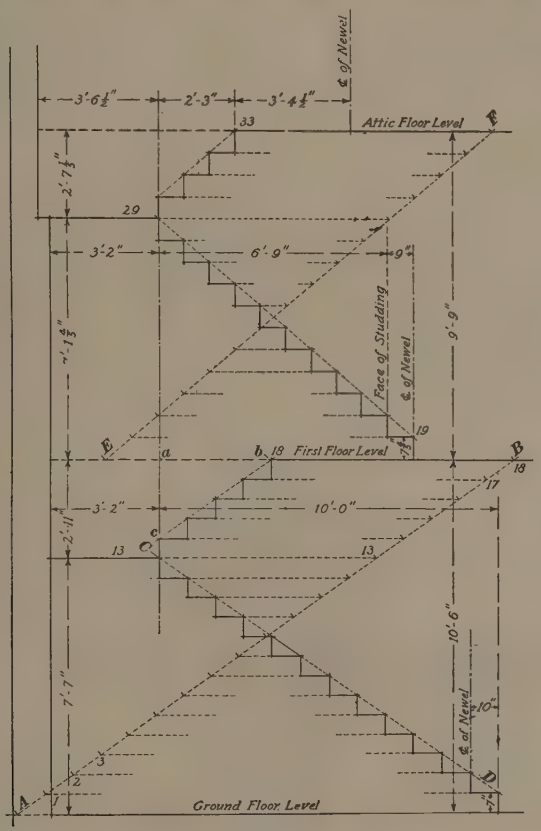


FIG. 48

$= 40''$ and draw the line $c\ b$. The process for finding the positions of the five risers is the same as that already explained.

152. The position of the risers on the staircase from the first floor to the attic floor can be fixed in the same manner; but as

it is not so important to have an easy and gradual rise on this floor, the number of risers may be less. If the height of 9′ 9″ is divided into 15 equal parts by the diagonally placed scale *E F*, the height of each riser will be $7\frac{4}{5}$″. The tread may be correspondingly reduced to 9″. As the width of this half-landing will also be 3′ 2″, the position of the first riser is fixed and will be at a distance of $10 \times 9'' + 3'\ 2'' = 10'\ 8''$ from the rear wall. Having determined the number of risers and the positions of the treads, the staircase may now be drawn in the plan.

153. Begin by setting out the position of the riser at the upper half-landing, which is 3′ 2″ from the rear wall. Draw a horizontal across the staircase at this point. To find the position of the riser below the first tread, indicated by the numeral *1* in the plan, set off along the kitchen wall a distance of 10′ 0″ and draw another horizontal at this point. From this horizontal set off divisions of 10″ to indicate the positions of the faces of the risers in the first flight. At the point where the second riser intersects the centre line of the hand rail draw a circle of $4\frac{1}{2}$″ diameter, and draw a square tangential to this circle to represent the first newel. On the other side of the staircase well set off the five risers that are situated between the landing and the first-floor level. As seen from the plate, the half-landing, the risers above it, and the hand rail are shown in dotted lines, as they are considered as belonging to the first floor. The upper part of the lower staircase is broken away to show the entrance door to the basement, which is situated below the half-landing. The jamb of this door and some of the treads are shown, the upper tread being numbered *10*, an arrow with the word *Down* indicating the direction of descent; a short arc and a radial line dotted in show the position of the door. Insert full lines parallel to the risers, shown in dotted lines, to represent the nosing of the treads, as shown on the plate. Details of treads and risers are found in Fig. 49. The first tread has an extension curving round the first

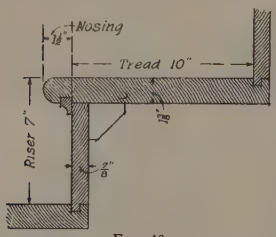


FIG. 49

newel ; the centre of the curve at the end is on the centre line of the rail and its radius is about 8″.

154. The door and window openings in the exterior walls shown in the ground-floor plan may now be drawn, beginning with the mullion window in the morning-room. Set off the centre line of the window at a distance of 7′ 7½″ from the angle *h*. Measure off for the central opening 13″ on either side of the centre line and draw the two mullions 8″ wide. Then set off the centre lines for the other openings at distances of 2′ 10″ from the main centre line, and draw the stone jambs, as indicated. Then draw the window-frame lines that indicate its thickness, the dimensions being obtained from the detail drawings, only the thickness of the frame and its distance from the face line of the wall being required.

Now draw the openings in the small bay windows of the morning-room and drawing-room according to the detail dimensions in Fig. 47 ; also show the openings in the large bay window in the drawing-room. Continue to insert all the window openings in the brick walls, working toward the right round the wall and finishing them in regular order.

155. The doors leading to the w.c. and scullery should now be drawn. By consulting Fig. 50, which is an elevation of that side of the building, these doors may be seen in elevation. On the ground-floor plan there is a note with an arrow at the door of the w.c. indicating that the top doorstep is raised 12″ above the ground level. Comparing the two views, it is seen that the front of the top doorstep is set flush with the plinth. In front of the other door there are two steps made of bricks on edge. The step marked *2* extends to the top doorstep. Draw now the cellar steps, which, as seen from Fig. 50, lead down to a door below the ground level. The note, *Down to Cellar*, together with the arrow, found in the ground-floor plan, indicates the direction in which the steps descend. Draw first the enclosing wall 9″ thick and 3′ 0″ from the face line of the wall. The length of this wall is determined by drawing the inner face of the end wall as a continuation of the corresponding face of the kitchen wall. The riser of the ninth step coincides with the

line $t t_1$, produced. As the overall dimensions of the treads of the steps are given as 6′ 9″, the risers may now be set off. Indicate also the iron railing by two parallel lines, as shown.

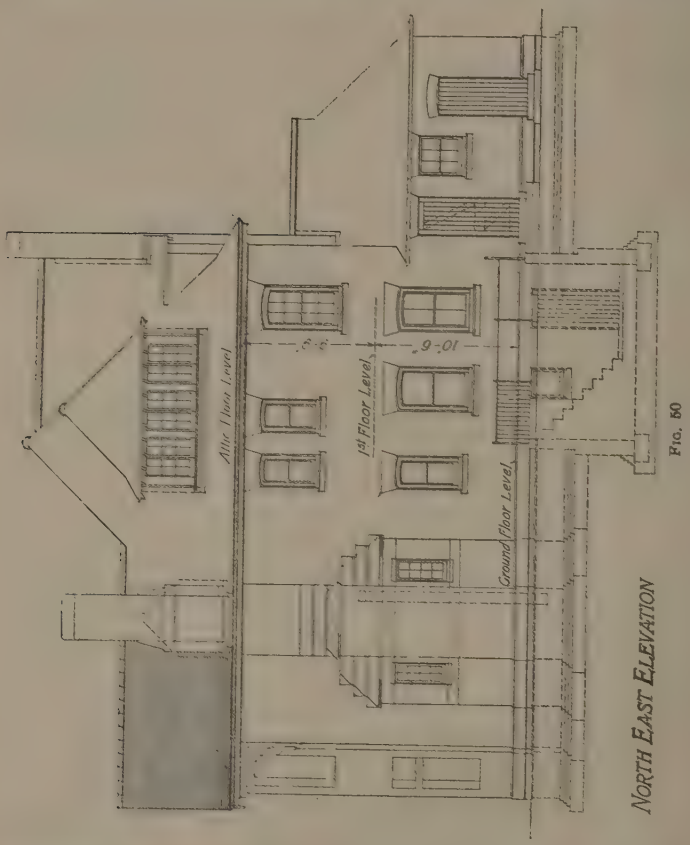


FIG. 50

Draw also the dwarf wall and brick paving at the front entrance according to the dimensions given in the plan.

156. The exterior work being completed, draw in the lines representing the kitchen sink, cupboard, and other details, also the boundary line of the cement floor in the kitchen. Show

the panelling with which the hall walls are covered, as indicated by a line parallel to the face of the wall. Also indicate the floor joists, which are shown by dotted lines in the various rooms. Indicate the pair of steel joists shown in dotted lines above the bay windows in the morning- and the drawing-room.

157. The pencil work now being finished, proceed to ink in the drawing, after which clean the sheet with a rubber and remove the pencil lines that have overrun at the angles and openings. Also ink the centre lines, but omit the reference letters for these and all other lines, except the section line *A B*. All information relative to doors, windows, flues, etc., should be written in full on the drawing. The names of the various apartments and fittings should now be inserted and thereafter the drawing coloured.

158. Colouring the Plan. – Before beginning to put on the washes, it is preferable, if these are to cover large areas, to dampen the whole plan with clear water in the manner already described. Begin with the floors of the rooms which are to be covered with thin washes of yellow ochre. Care should be taken to keep within the boundary lines, at the same time avoiding white patches inside the lines. The aim should be not to work the brush over any particular place more than once, so as to avoid any spotting by the dissolving of the ink. The light washes of scarlet lake for the brick paving and the hearths may be laid on next, then the wash for the cement floors in the store rooms, kitchen, and cellar steps. It is not advisable to lay on a wash when that on an adjoining surface is not quite dry, as there is a possibility that the colour may flow from one into the other. The wash for the cement floor consists of scarlet lake to which is added a little Prussian blue.

159. A light wash of Prussian blue may now be laid over the stonework of the cellar steps and wall, the front porch steps, the stone curb round the hearth of the inglenook, the window sills, etc. It is observed that the steps leading down from the rear hall to the basement are of stone, but only parts of the upper four treads are here visible. Prepare now a light wash

of vandyke brown with which to cover the treads of the staircase in the rear hall, the window sills, seats, etc. Then, with a more dense wash of the same colour, cover the part of the woodwork shown in section, such as the door and window jambs, panelling, etc. A mixture of Payne's grey and water of the density shown on the plate is prepared for the stonework that is shown in section, as, for instance, the window jambs and sills. Finally, the brick walls are covered with a wash of scarlet lake, but this should not be too dense. The copper shown in the scullery may be covered with a thin wash of scarlet lake to which has been added some Prussian blue. The wooden cover is coloured a light vandyke brown. Finally the main title is added, drawing guide lines for it at distances of $\frac{3}{8}''$ and $\frac{7}{8}''$ from the upper border line.

A complete tracing is to be made from the finished drawing plate, but without adding any washes of colours or any section lining. In an architectural drawing office a black-line print would be made from the tracing ; the print would be coloured in the same manner as the drawing plate and would then be delivered to the contractor, although in some cases the original linen tracings are coloured and sent to the contractor who will use them as working drawings.

BASEMENT PLAN

160. Footings and Foundations.—Unless brick or stone walls rest directly on rock, a **base,** or **footing** with **foundation,** is built under them. These footings, with their foundations, may consist of concrete, stone, or brick, and are wider than the wall, their purpose being to distribute the weight over a larger area than that offered by the wall itself and to add stability to it. The width of the foundation will depend on the character of the soil on which it rests. Concrete consisting of broken stones and cement makes a satisfactory foundation in most cases, as it is practically equivalent to a solid stone beam on becoming hard. Where footings are made of brick, the bricks are usually built in several courses, each course projecting about $2\frac{1}{4}''$ beyond the one above until the required width is obtained.

161. In general, a preliminary cellar or basement plan of a house is made on a piece of tracing paper or tracing cloth placed over the finished ground-floor plan, the arrangement of the latter plan being considered of first importance and the details of the basement usually arranged with reference to the floor above. Afterwards, the basement plan is made on drawing paper in the usual manner. In Fig. 51 is shown a plan of the basement enclosed with brick walls, which also surround the outside cellar steps. This plan is taken at a level below the plinth course.

162. The changes in dimensions of the walls, which occur at various places of the basement, are shown by means of several sections taken along the lines indicated on the plan. It will be seen from these that the outer brick wall has a thickness of 18″ below the plinth course and that the footings consist of three courses, of which the lowest is 27″ wide. The concrete foundation below the footings is 12″ thick and 3′ 0″ wide. There is also a layer of concrete throughout the basement 6″ thick, this layer being integral with the foundation. It will also be seen that some parts of the wall are made $4\frac{1}{2}$″ thicker below the plinth course for the purpose of supporting the joists and to add to the general strength of the wall. In order to distinguish between those parts that are made thicker and others that retain a uniform thickness down to the footings, the following method is usually adopted: Referring to Fig. 51, an angle at a_1 is seen indicated in dotted lines. The dotted line $a_1\, a_2$ is supposed to continue toward point b_1, but generally only a short length of it is shown. This imaginary line $a_1\, b_1$ indicates that the inside face line of the wall above the plinth course is thinner by an amount equal to the width $a\, a_1$. The same is indicated by the line $e\, e_1$ and other lines similarly placed. The dotted line $f\, g$ in section $A_1\, B_1$ indicates that the footing is symmetrically arranged relative to the main wall and that the additional material has been placed on the inside of the wall. Incidentally, this section, by considering the dotted line as the inner face, will represent a section of the wall at the line $c\, d$, as this portion of the wall has a thickness of $13\frac{1}{2}$″ below the

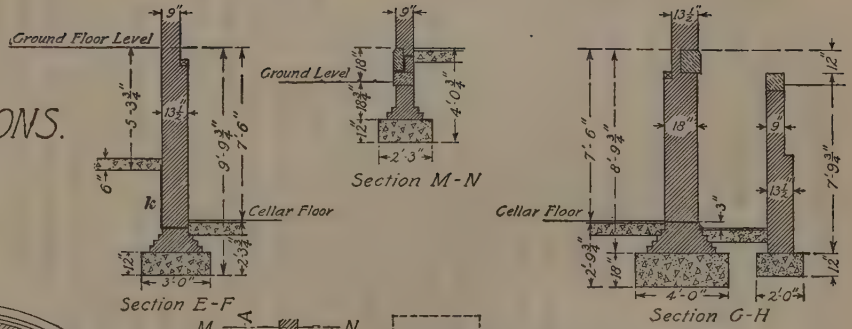
plinth line. The dotted line beginning at h is assumed to continue from point h round the bay, and the dotted line at h_1 is supposed to continue round the rear bay toward the side wall; it follows, therefore, that the walls at these places decrease in width to 9″ at the ground-floor joists.

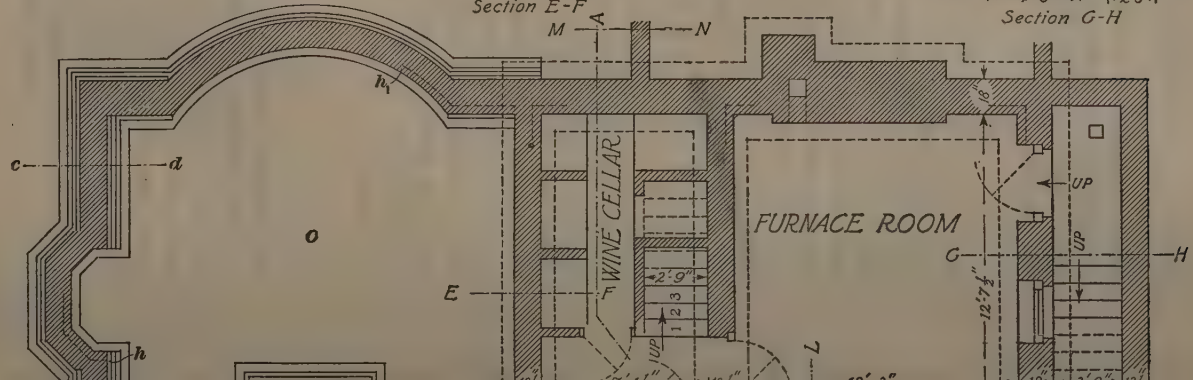
163. The necessity for giving several sections of the basement wall is caused by the fact that the level of the basement floor is not the same throughout. In the compartments O, P, Q, R, and S the height of the ground floor above the foundation base is 5′ $3\frac{3}{4}$″. This height is here greater than usual, and was made so as to give a large ventilating space below the floor and also to give means of access to this space, if necessary. In the furnace room and wine cellar the height has been increased to 9′ $9\frac{3}{4}$″; the cellar floors in these compartments are at a distance of 7′ 6″ below the ground-floor level. In section C D the wall between compartments P and Q is seen to be 9″ thick. Between these compartments there is an opening i in the wall, its lower side being on a level with the top of the concrete foundation. The section E F shows that the wine cellar has a height of 7′ 6″ and that its floor is 2′ $3\frac{3}{4}$″ above the foundation base. The damp course, indicated by the heavy line k, extends from the cellar floor through the wall and along the face of the wall up to the concrete floor in the adjoining compartment. The vertical part of this damp course, which is $\frac{3}{4}$″ thick, is in the form of two layers of natural asphalt. In the absence of this layer moisture might pass through the wall to the wine cellar, which preferably should remain dry.

164. Section G H passes through the furnace-room wall and that of the cellar steps, and shows the different levels of the two floors. Section K L is another section through the furnace room, showing the difference in level between its floor and that of compartment S. In all of these sections the heavy black line indicates the damp course. The section through the rear addition at M N shows that the space below the scullery-floor level is reduced to 4′ $0\frac{3}{4}$″ in height, the thickness of the wall is here reduced to 9″, and the width of the foundation to 2′ 3″. The damp course is here laid along the plinth course.

BASEMENT PLAN

BASEMENT PLAN SHOWING FOUNDATIONS.




WINE CELLAR
FURNACE ROOM
UP
UP
UP

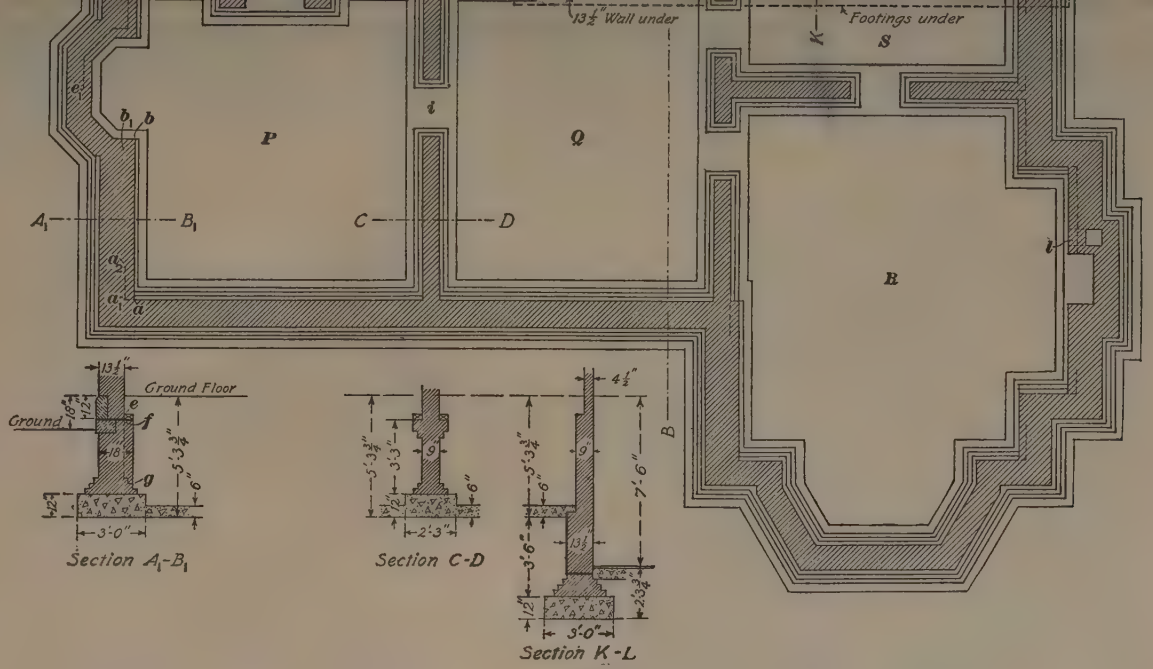

13½" Wall under
Footings under
P
Q
R
S
A1
B1
C
D
K
L
Ground Floor
Ground
Section A1-B1
Section C-D
Section K-L

FIG. 51

§ 21

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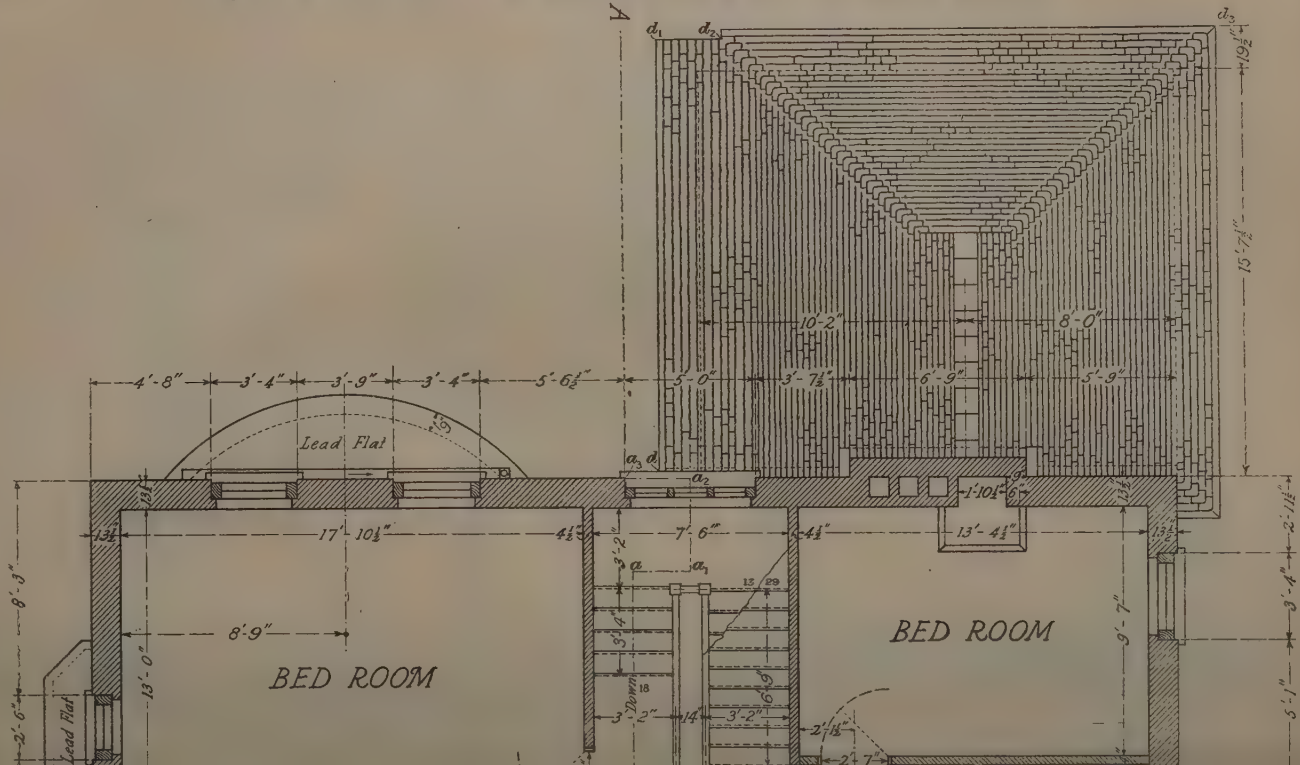
FIRST-FLOOR PLAN



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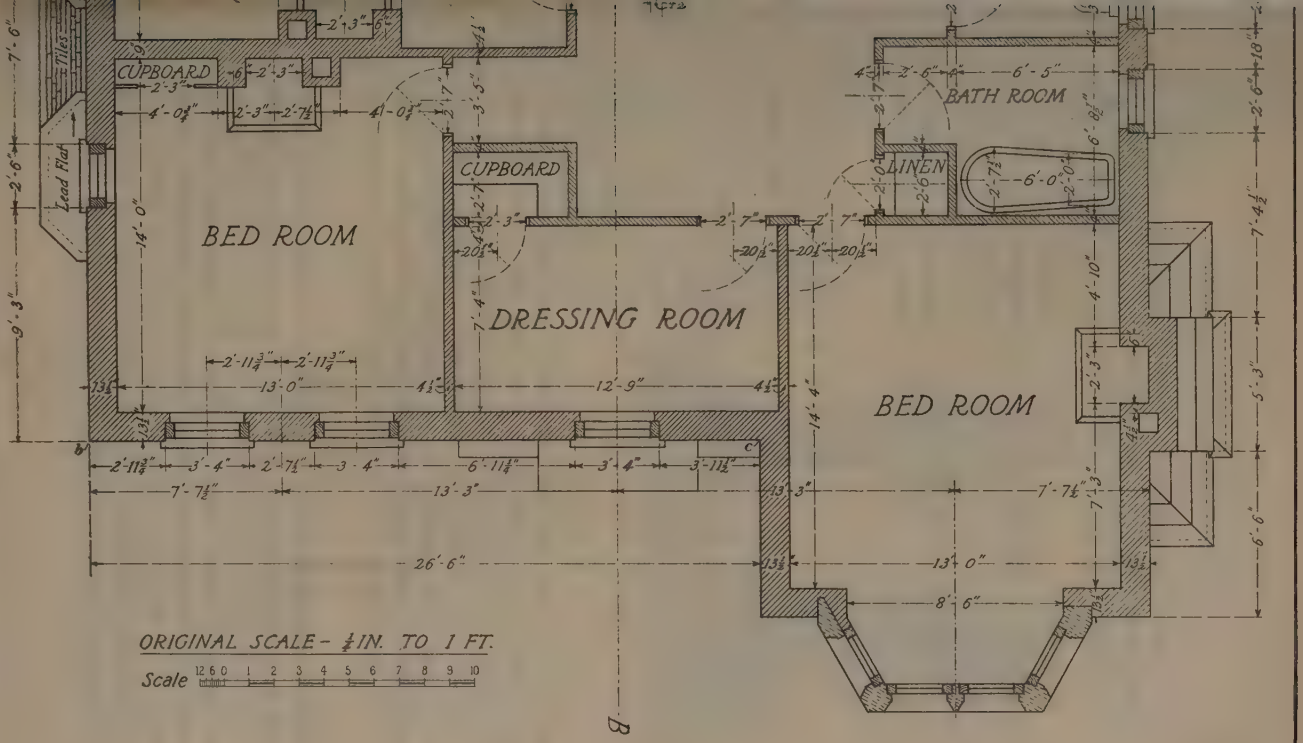

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To facilitate the ventilation of the basement, the outside wall is at certain intervals provided with air bricks, constructed as shown in Fig. 52 (*b*). Additional means for ventilation are found in the flue at *l*, Fig. 51, which extends up through the inglenook to a point above the first-floor level, where it communicates with the outer air.

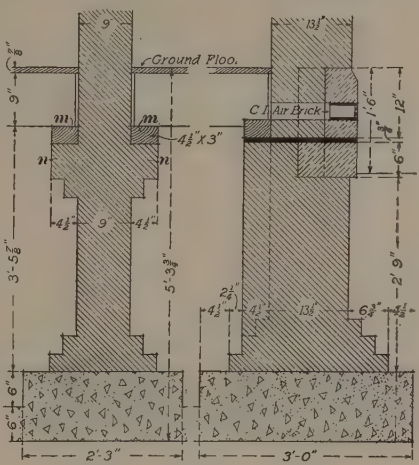


Fig. 52

165. In the section, Fig. 52 (*a*), which resembles the section *C D*, Fig. 51, parts *m* are *wall plates*, which rest on the corbelling *n* and support the joists in the ground floor. The note: $13\frac{1}{2}''$ *wall under*, found in compartment *Q*, indicates that the wall at this place increases below the floor to a thickness of $13\frac{1}{2}''$. This may also be seen from section *K L*; otherwise the drawing may be easily understood. The position and form of the walls under the inside cellar steps may not be understood from Fig. 51 alone, but the plate entitled *Section A–B*, which is to be drawn subsequently, gives the additional information required.

DRAWING PLATE, TITLE: FIRST-FLOOR PLAN

166. In practice, the architect works up the first-floor plan of a house by covering the ground-floor plan with a sheet of tracing paper and works out the principal features directly over those underneath. The finally determined positions of such parts as the stairs and chimneys can thus be transferred to the first-floor plan and the partitions of minor importance arranged accordingly. Partitions should preferably come over one another.

167. Begin the plan by drawing the section line *A B* from *B* to *a* at a distance of $6\frac{3}{8}''$ from the left-hand border line, this portion of the line also serving as a centre line. The face line *b c* should be 4″ above the lower border line ; the position of point *b* relative to the centre line *a B* is fixed by the dimensions given. Proceed by fixing the positions of the angles on the outer face line of the building in accordance with the instructions given for drawing the ground-floor plan. Then draw the inner face of the outside walls and fix the positions of the walls and partitions from the dimensions given. After the drawing of the walls and partitions has been completed, it will be seen, by comparing the ground-floor with the first-floor plan, that many of the walls and partitions occupy the same relative positions as those underneath them, thus affording a continuous construction. Next draw the chimney breasts in which are situated the fireplace openings. Draw the door openings in the walls and partitions according to the method followed in the ground-floor plan and indicate the doors in the manner shown.

168. Now draw the main staircase. Observe that the positions of the newels are the same as those that are shown on the ground-floor plan. Indicate the centre line of the newels, which here coincide with the dotted face line of the first and last risers. Draw the newels at the landing and fix the positions of the riser belonging to the tread marked *19* from the dimensions given. The curve that forms the end of the tread of this riser has its centre at the angle of the adjoining wall. The upper part of this staircase, together with the half-landing and the five steps that lead up to the second floor, have been broken away, so that the stairs down to the ground floor are shown on the plan. Draw in the centre line of the hand rail for each flight, fixing its position from the face line of the nearest wall. Divide the distance between centre lines of newels into the number of spaces shown for each flight, and draw through the division points lines at right angles indicating the positions of the risers. Parallel to these lines draw other lines to represent the noses of the treads at the distance indicated in Fig. 63. Now draw the outlines of the hand rails, which have a width of 3″, as seen from Fig. 63.

169. The window openings in the exterior walls are now to be drawn ; their positions are in some cases fixed by means of their centre lines, in others by measurements giving the positions of the jamb lines. The dimensions of the bay window in the right-hand front bedroom are obtained from the ground-floor plan. The lead flats over the bay windows in the morning-room and the drawing-room on the ground floor should now be drawn ; the dotted lines in these flats represent the face of the window frame below. That the flats slope toward the garden seat for the purpose of shedding the rain-water is indicated by the arrows.

170. Before proceeding any further, it is necessary to extend the centre line $B\ a$, so as to serve as the section line $A\ B$ through which a vertical section is taken later on. At point a this section line turns to the right to point a_1 and then upwards to point a_2. The line $a_1\ a_2$ coincides with the centre line of the staircase and of the rear window, through which it passes. It will therefore be at a distance of 3′ 9″ from each of the partitions. From a_2 the line proceeds to the angle a_3 and then to A.

171. The roof over the scullery may now be drawn. In the ground-floor plan the projecting parts of this roof have already been indicated in dotted lines. The scullery extension is also shown in the first-floor plan in dotted lines, beyond which the eaves with gutters overhang for a distance of 19½″. As seen from the dimensions, the ridge is not centrally placed, being 2′ 2″ nearer to the right. As the slope is the same on both sides of the ridge, it follows that the gutter at $d\ d_1$ must be lower than that at $d_2\ d_3$, hence the latter gutter must end at d_2. On the plate the gutter is seen to project a distance of 3″ beyond the roof. Set off the ridge line from the dimensions given and draw the hip lines from points d_2 and d_3 at an angle of 45° to the horizon, so as to intersect the ridge line at the same point. On the plate these lines do not actually meet the ridge, as there is a small gable at the end of the latter. The total length of the ridge, inclusive of the gable, is to be 8′ 8″. These lines may suffice to indicate the roof ; if more details are desired, then the tiles over the ridge and the hip lines may be drawn. It is not customary

on ordinary architectural drawings to indicate the remainder of the tiles in the manner shown on the plan.

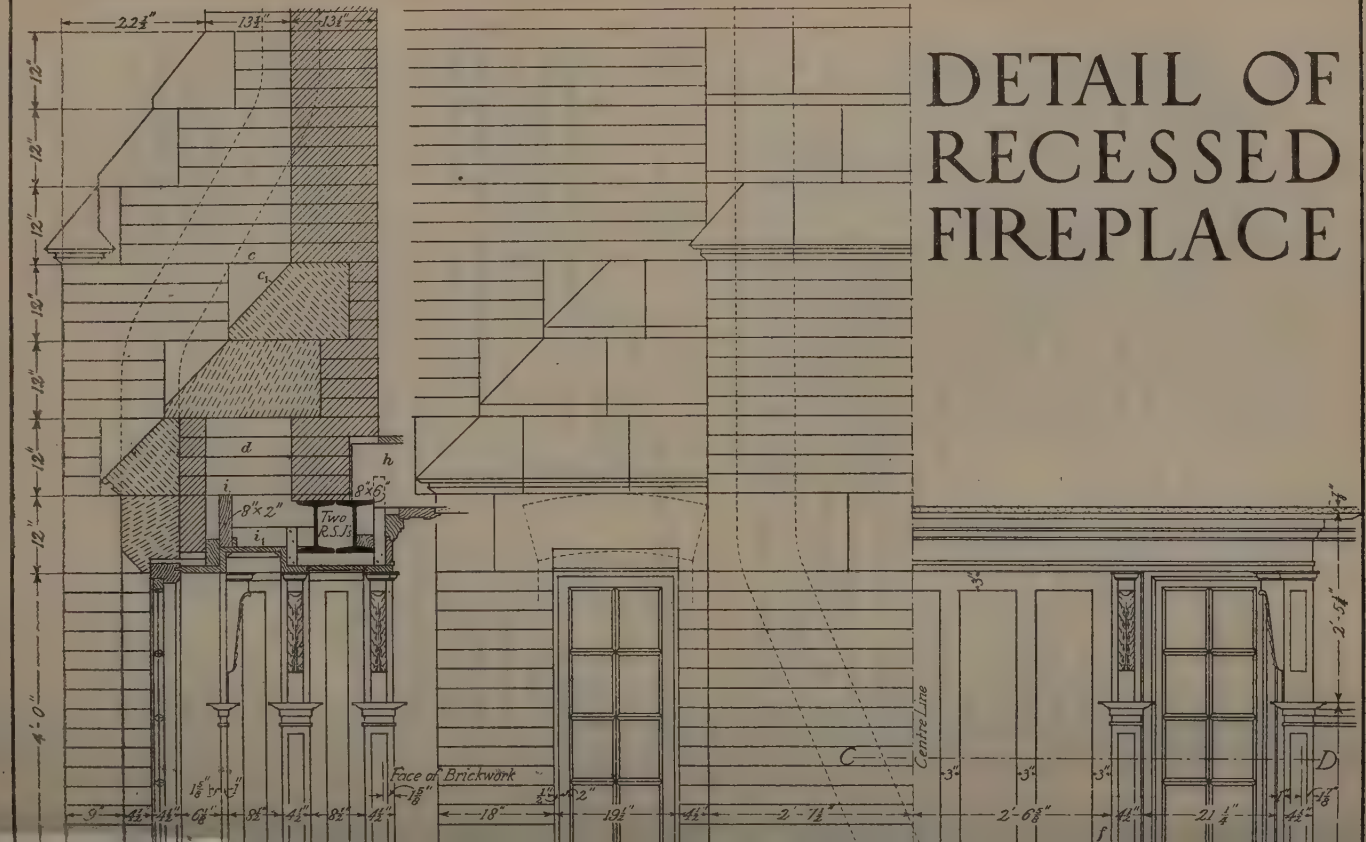
172. Now proceed to draw the projecting stone courses over the recessed fireplace, or inglenook. The dotted lines represent the face lines shown on the ground-floor plan, while the extreme outline indicates the overhanging part of the first stone course, the amount of the overhang being 3″. This feature is shown more clearly in the elevation, Fig. 50. Each course projects beyond the one above for a distance of 10″, except at the central part at the chimney itself, where the amount of projection is only 8″. The exterior work is now finished and the interior details may be drawn, such as the fireplaces, hearths, cupboards, bathroom fittings, etc. In many cases the bathroom is provided with a fixed lavatory basin, but it has been omitted from this plan. Finally, insert the dimensions, names, and title. This plate is to be coloured and traced in the same manner as the ground-floor plan, but not section lined.

DRAWING PLATE, TITLE: DETAIL OF RECESSED FIREPLACE

173. This plate gives the details of the fireplace that is situated in the dining-room, shown on the ground-floor plan. In the plate to be drawn, the principal view is an elevation of the fireplace, of which the part to the left of the centre line represents half the external elevation and that to the right half the internal elevation of the fireplace. One half the plan is taken along the line *A B* of the elevation and the other along the line *C D*. The section is taken along the line *E F* in the plan. A clear idea of the general appearance of this fireplace may be had from the perspective view, Fig. 53.

Begin the plate by drawing the vertical centre line at a distance of $4\frac{5}{16}$″ from the right-hand border line; then draw the floor line of the elevation $4\frac{3}{4}$″ above the lower border line. Draw a line to indicate the internal face of the wall in the plan at a distance of $3\frac{5}{16}$″ above the lower border line, and let the corresponding face line in the section be $3\frac{9}{16}$″ from the left-hand border line. In both of these views draw another line

DETAIL OF RECESSED FIREPLACE



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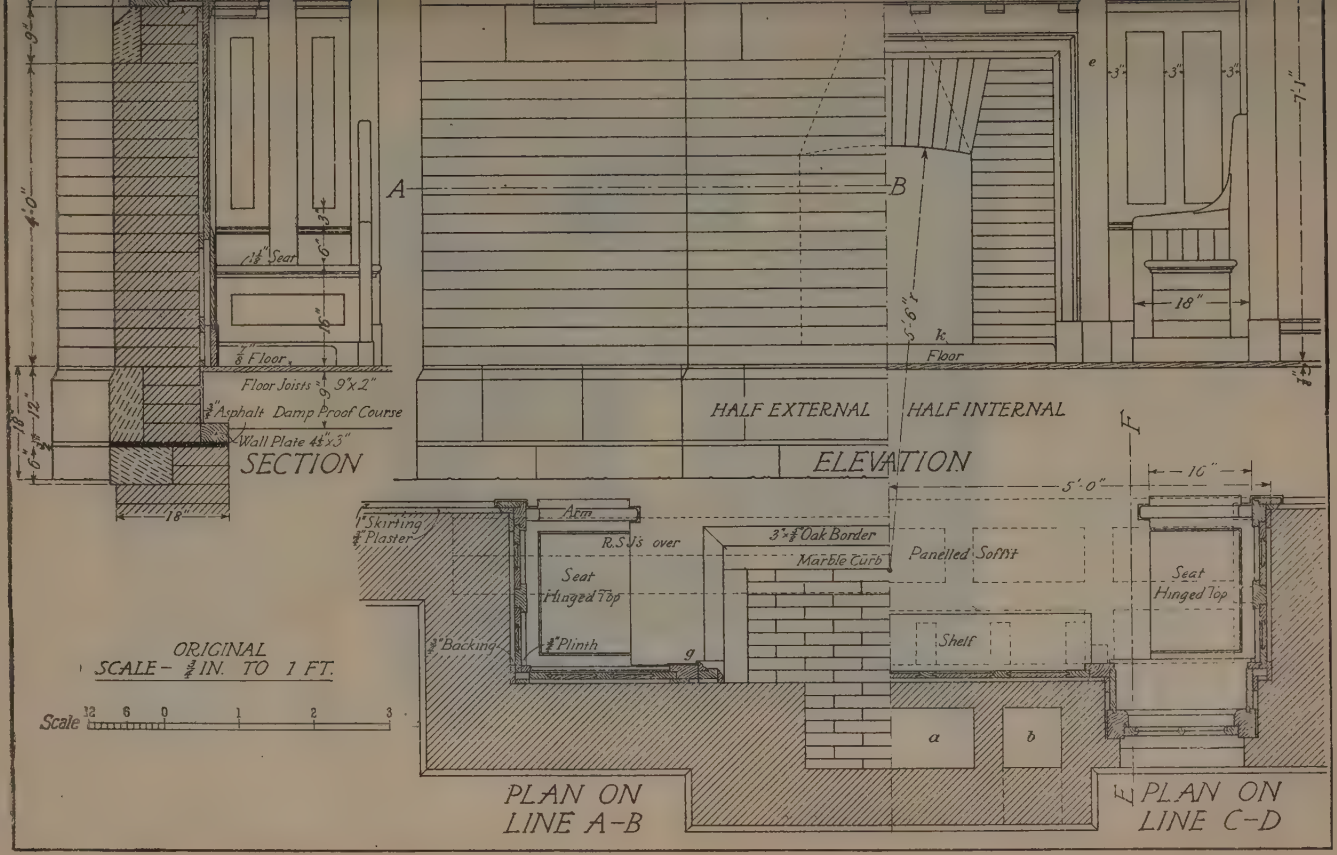

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parallel to each of these face lines, and at a distance of $13\frac{1}{2}''$, to represent the outside face of the wall. Then, at a distance of 3′ 0″ to the left of the outer face line in the section, draw the face line of the chimney and set off on this line the height of the brick courses. Through the points of division draw horizontal lines across the plate up to the centre line. By means of these

Fig. 53

lines the positions of the more important points may easily be determined.

174. Some explanations are here required with reference to the internal half of the elevation. This elevation represents the left-hand half of the plan as viewed from within, but as the halves are similar, with one exception, the internal half of the elevation has been projected from the right-hand half of

the plan. The feature that differs in the half-plans is the flue, which, as seen from the elevation, inclines to the left. The greater part of the flue will therefore be contained in the left-hand half of the elevation. As this half is also shown in the internal elevation, it follows that this part of the flue should be shown there in dotted lines; but, as seen, it shows the part of the flue that passes through the right-hand half of the plan. This deviation from a strictly correct elevation is made for the purpose of showing the remaining part of the flue, this being the only view where the complete outline can be shown.

175. As already explained, it is preferable that similar parts in the three views should, as far as possible, be drawn in succession. Therefore, beginning with the plan, draw the angles of the wall and the recess and project these lines to the elevation. In the plan there are shown two openings *a* and *b*; the latter is the ventilating flue from the basement already mentioned. By comparing the plan and elevation, it is seen that, as the flue inclines to the left after leaving the fireplace, there will be quite a broad expanse of brickwork between the two flues that will not serve any particular purpose. To avoid this waste of material, there is left a hollow space between the flues that extends nearly up to the hearth on the first floor. The opening *a* in the plan represents this wedge-shaped cavity as it will appear in a section along *C D*. In the elevation this cavity has not been shown, as the bricklayer will provide for it and the dimensions will vary according to the positions of the bricks in the wall. A saving of material is also obtained by leaving an open space at *d* in the roofed part of the fireplace.

176. Proceed now to draw the outlines of the wall in the section, indicating the positions and forms of the various stone courses. It is noticed that of the end stones in these courses the part that projects into the brick wall is square, while the exposed part is splayed, as seen at *c* and c_1, respectively, in the top course of the fireplace projection.

177. The window openings may now be shown in the plan, section, and external half of the elevation. Indicate also in dotted lines the brick arch over the window in the latter view,

letting the top of the arch be tangential to the base of the stone course above and describing the arc with a radius of 4′ 8″. As seen from the section, this arch is inside the stone lintel. The woodwork of the windows may now be drawn from the general dimensions given, obtaining additional dimensions by scaling the plate.

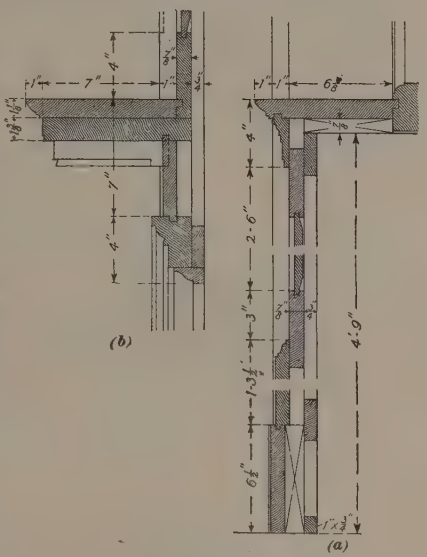


FIG. 54

178. Details of the window board are found in Fig. 54 (*a*), which also shows the panelling below. These parts may now be drawn in the section together with the floor, joists, and wall plate. Details of the shelf over the fireplace opening are given in Fig. 54 (*b*); in the section this shelf will also be visible, as this view is taken on the line *E F* in the plan looking toward the shelf. The panelling in the plan should now be drawn, beginning with the right-hand end in the rear of the seat. Complete details for this part of the panelling and also for the window lining are found in Fig. 55 (*a*), which is a plan corresponding in position to that on the plate. At *e* in this view is shown the pilaster, which, as shown at *e* in the internal half of the elevation, extends from the floor to the ceiling. Adjoining this member is a stile *f*, 3″ wide. The spacing of these parts in the plan may be obtained from the elevation on the plate.

179. The panelling in the left-hand half of the plan is similar to that in the right-hand one, excepting the part below the window. The architrave and pilaster situated at *g* in the plan

are shown in detail in Fig. 55 (*b*), but in a reversed position; the remainder of the panelling is similar to that shown in the other half of the plan. The panelling in the section can now be drawn, obtaining some of the dimensions from Fig. 56, which is

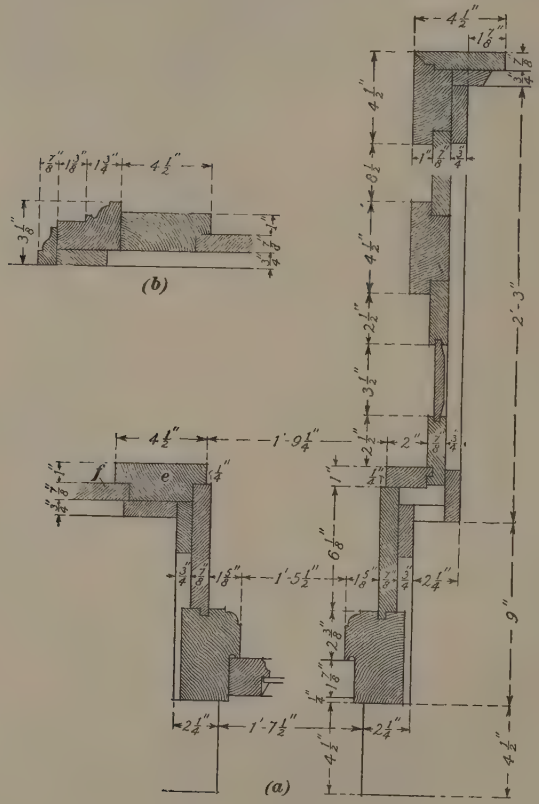


FIG. 55

a section through the ceiling and through the two rolled-steel joists that support the wall above the fireplace. For the purpose of supporting the ceiling at this place, there is provided some rough framing that is arranged as follows: Resting on the steel

joists are floor joists h, and supported in the wall is a joist i, which supports one end of the bracketing piece i_1, the other end resting on the flange of the steel joist. To i_1 is nailed a piece i_2, which supports one end of a piece i_3. To the other end of this piece is nailed a strip i_4 fastened to the joist h.

180. In Fig. 56 are given the dimensions required for drawing the pilasters and the ceiling; the ornaments on the pilaster

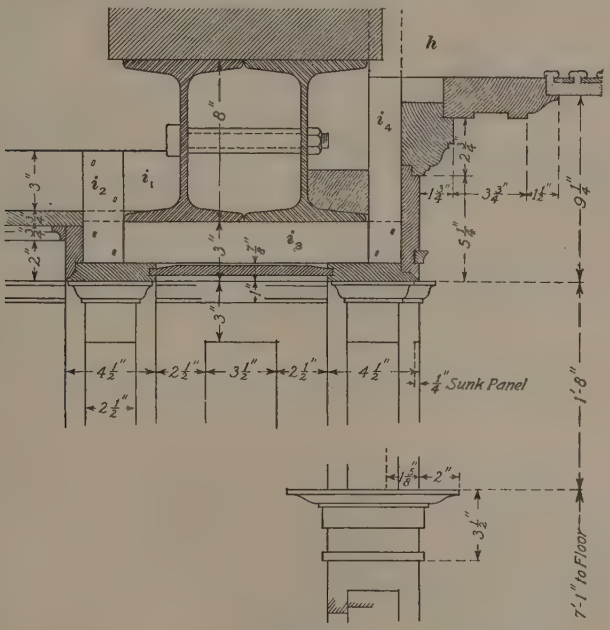


Fig. 56

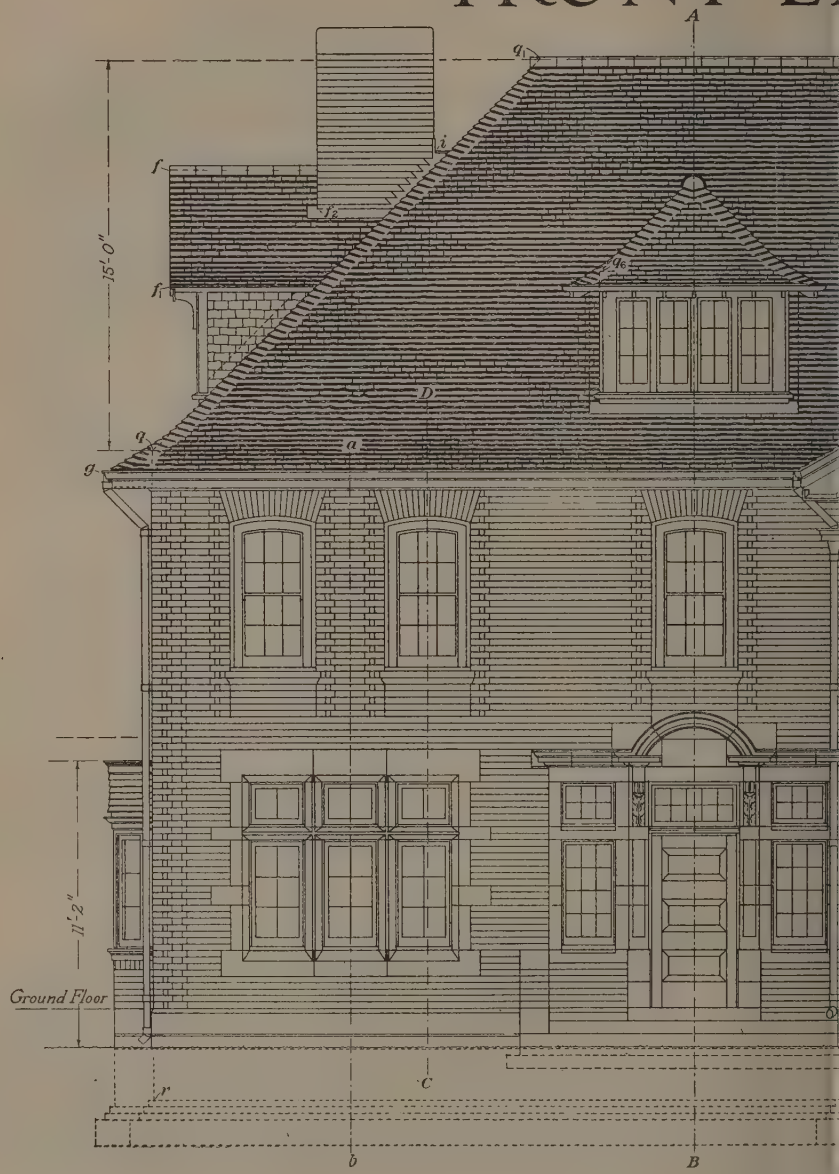
brackets may be omitted. Draw the seat in the section by means of the dimensions given. Details for the cornice round the ceiling may also be found in Fig. 56. After drawing the latter part in the section, the principal lines should be projected over to the elevation to show the cornice in elevation. In Fig. 54 (*b*) are given the details for the shelf over the fireplace and the architrave round it. The seat should also be shown in

the elevation, some of the lines being projected from the section and others obtained by scaling the plate. Then show the brick arch over the fireplace and the brick courses at the side. The line at *k* in the elevation indicates the upper side of the marble curb round the hearth. The two seats in the plan may now be drawn, also the hearth, and the panelled soffit, which is shown in dotted lines in the plan. This plate is to have the parts in section coloured in the same manner as the ground-floor plan. Regarding the colouring of the surfaces shown in elevation, reference is had to the remarks made in Art. **50.**

181. It is desirable that the washes in the elevations shall not appear too flat ; in fact, some gradation of tinting is quite permissible as tending to produce a more picturesque effect. Therefore, after the surfaces have been covered with a wash, some parts of the surfaces are given a second wash. Glass surfaces, shown in detail drawings, can be covered either with a flat wash of light blue or by a few strokes of this colour in the upper left-hand corner of the pane. A pleasing effect may be obtained by colouring window panes by a wash that is dark blue at the top, gradually shading off to a light blue at the bottom. This dark blue may be made by adding lampblack to Prussian blue. In colouring elevations, it is advisable to put the lighter colours on first, because, if some of these colours should overrun the boundary lines of a surface, they would be covered by a darker colour that later would cover an adjoining surface. All large surfaces should be covered with a light transparent wash.

182. In colouring detail drawings, care should be taken that *all* the surfaces are covered with colour and that none are left white. For instance, in the plate *Detail of Recessed Fireplace* the space between the two steel joists over the fireplace should be tinted a brick colour, as bricks are situated in the rear of the opening. The same tint should be given to the space at the left of these joists over the cross-piece i_1. The elevation of the brick arch, back, and jamb to the fireplace opening should be coloured a tint different from the general brickwork, as they are made of special bricks. The elevation of the damp course may be coloured purple, and leadwork with light lampblack and scarlet lake.

FRONT E



ORIGINAL SCALE - 4
Scale

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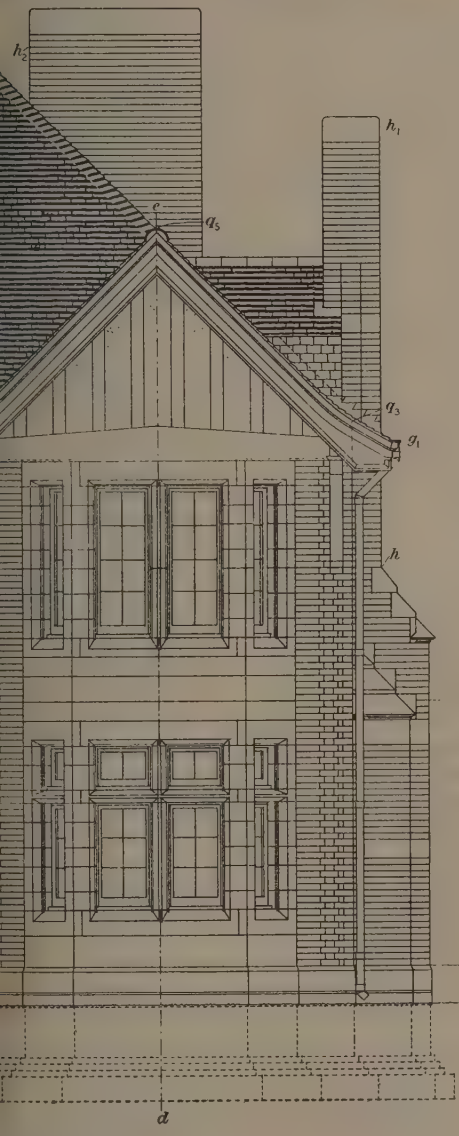
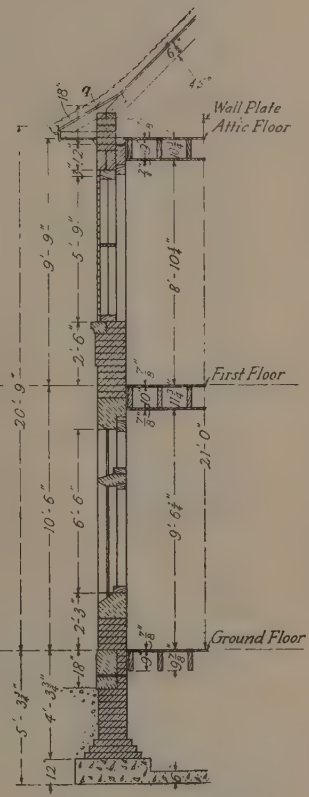
EVATION





Section on C-D

TO 1 FT.

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DRAWING PLATE, TITLE: FRONT ELEVATION

183. This plate shows a **front elevation** of the structure of which the ground-floor plan and first-floor plan have already been drawn. To these plans, in particular to the ground-floor plan, reference should frequently be made for any additional dimensions required, and also for the outlines of some of the parts, such as bay windows, the recessed fireplace, etc. The plate contains also a *section*, taken along the line *C D*, which indicates the general construction of the building, and also contains the leading heights of the structure. This section, when carefully drawn, will give the accurate positions of the various horizontal subdivisions of the wall, from which all the horizontal lines in the elevation may be projected.

184. The more important features of the section should be drawn first and with particular care, so as to secure a satisfactory projection of the elevation. Draw a vertical to represent the outer face line of the wall near the ground floor at a distance of $2\frac{1}{2}''$ from the right-hand border line, and draw the base line of the foundation at a distance of $1\frac{3}{8}''$ above the lower border line. Draw the ground-floor level at a distance of $5'\ 3\frac{3}{4}''$ above the base line, the first-floor level at a distance of $10'\ 6''$ above the ground-floor level, and the attic-floor level at a distance of $9'\ 9''$ above the first-floor level. Now draw the basement wall, showing the foundation, footings, and plinth course. The dimensions of the foundation wall at this place correspond in general with those shown in section $A_1 B_1$, Fig. 51, assuming that the dotted line *e g* represents the inner face of the wall.

185. Now draw the wall above the ground floor, referring to the ground-floor plan for the required dimensions. Show the stone sill and lintel and the woodwork of the window on the ground floor. Draw also the window opening for the first floor; the brick arch over this window is $12''$ high at the centre, but at the springing line it is $15''$ high, and the wall above it $15''$ high. In order that the pitch line of the roof may be drawn, produce the outer face line of the wall and measure off a distance of $18''$ from the top of the window brick arch, thus

obtaining point q, which is shown in the section and also in the elevation. From this point draw a line at an angle of 45° with the horizon; this line gives the pitch of the roof and will also be the line along which the lower ends of the hip tiles will lie.

186. It will be noticed from the detail drawing, Fig. 57, of this part of the roof that the rafter stops at the wall plate a, and

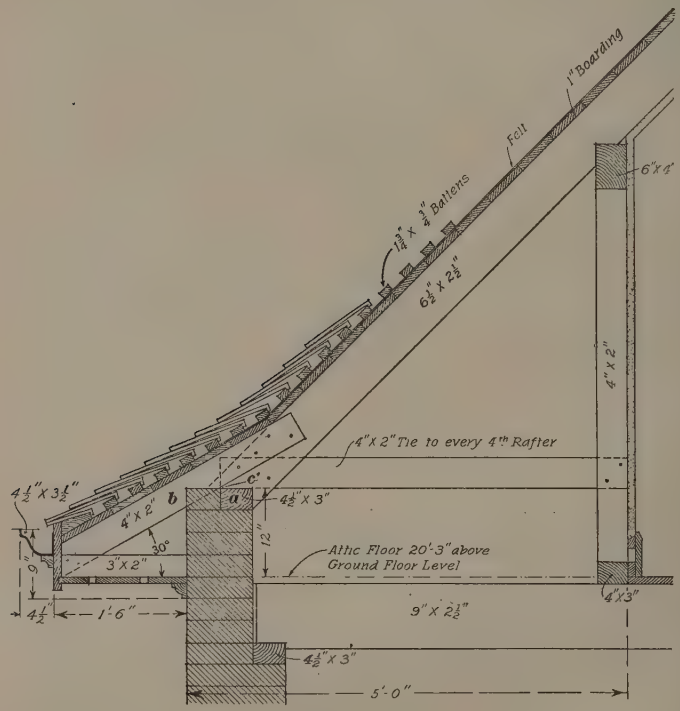


Fig. 57

that the eave is formed by means of a sprocket b fastened to the rafter. The upper side of the sprocket does not form a continuation of that of the rafter, but makes an obtuse angle with it. To fix the position of this sprocket, draw a line through point c at an angle of 30° to the horizon, and let its extreme point

be at a distance of 1′ 5″ from the wall. The other dimensions of the sprocket may be obtained from Fig. 57. By adding the floor joists and floors, the section, shown on the plate, may be completed.

187. The elevation is begun by projecting from the section the base line of the foundation and the plinth course, both lines being drawn across the space to be occupied by the elevation. Now draw the centre lines and angles of the building. Place the main centre line *A B*, which passes through the entrance door, at a distance of $6\frac{1}{2}$″ from the left-hand border line. On the ground-floor plan the line *A B* occupies a position corresponding to that of this centre line. Therefore, set off along the base line on both sides of the centre line *A B* points to indicate the positions of the various centre lines and angles, the distances being taken from line *A B* on the ground-floor plan. By this means the positions of the centre lines *b c*, *d e*, and angles *h*, i_1, i_2, i_3, i_4, i_5, i_6, *p*, o_1, o_2, and o_3, shown in the ground-floor plan, are fixed. Through these points draw vertical lines, as shown. Now project to the angle *q r* from the section the total height of the brick wall and subdivide this height into smaller divisions to represent the brick courses. Through these points of division draw horizontal lines across the elevation. Commencing at the first brick course below the eaves work downwards, drawing fine horizontal lines the full width of the elevation, leaving the question of length to be decided when the vertical lines are projected. The positions of the window and door openings may now easily be found, likewise those of the lintels, jambs, etc. In practice, these lines indicating brick courses would be drawn last.

188. The angles of the bay window at the centre line *d e* may be found by pinning the ground-floor plan over the drawing, so that the centre lines *d e* lie in line, and then project from the plan the required points to the ground-floor line. This method is followed wherever possible. Or, if more convenient, a small tracing may be made from the particular part on the plan, and, after fastening this to the elevation, project from it the points desired. Some of these dimensions may be transferred by means of a pair of dividers from one plan to another.

189. When drawing the windows at the centre line *a b*, it will facilitate the drawing if the positions of their centre lines are first fixed. From these centre lines mark off a distance on each side equal to one-half the width of the opening, and through these points draw vertical lines from the sill to the stone lintel course. This being done, set off a width of 2″ from one of these jamb lines as the width of the window frame ; set off this distance on both sides of the centre lines for each of the mullion windows. The width of the sashes may be set off in the same manner and also the splayed angles of the jambs ; for the sills and lintels these angles may be projected from the section. The windows on the first floor are drawn in a similar manner.

190. When drawing the side windows in the bay, reference must be had to the ground-floor plan. The various distances required from the centre line *d e*, in order to fix the positions of the angles, may be found in the manner described in Art. **188.** Verticals may then be drawn through the points thus found to indicate the jamb angles in elevation. Their lengths are obtained by projection from the section. If other detail dimensions are required, then reference must be had to the particular plate where these parts are shown in detail. It should always be remembered that none of these plates is complete in itself, but that the plates mutually complement one another.

191. When the drawing of the bay windows is begun, there will be no difficulty in drawing the two windows near the centre, but as the side windows are placed in walls that form an angle with the main wall, their dimensions of width will be shortened. By reference to the ground-floor plan, it will be seen that while the measurement of the side of the bay window is 4′ 0″, this is reduced to 1′ 11½″ when projected to a continuation of the front line of the window. Any subdivision of the side will be reduced in proportion. Observe, also, that one of the jambs is turned toward the observer and that the other faces in the other direction. In the former case the stone jamb, and the jamb of the window frame, and also the sash, can be shown, while in the latter case they are hidden by the corner stone jamb. All the lines of the window frame are not shown, owing to the small scale.

Draw the bay windows on the first floor in a similar manner. The entrance doorway with its windows may now be drawn, detail measurements being obtained from the plate entitled *Detail of Entrance.*

192. The roof lines may now be drawn in the following manner: From the point q, which corresponds with a similar point in the section, draw a line $q\ q_1$ at an angle of 45° to the horizon. At a point 15′ 0″ above q draw the horizontal dotted

FIG. 58

line $q_1\ q_2$ intersecting $q\ q_1$ at q_1. The dotted line $q_1\ q_2$ represents the line of intersection of the front and rear roof surfaces. The point q_3 at the other end of the roof is found in the same manner, and if a line is drawn from q_3, inclining at 45° to the horizon, it will intersect $q_1\ q_2$ at q_2 and thus determine the length of the ridge $q_1\ q_2$. The point q_4 is situated on the line that represents the angle at the entrance, and its position is found by projecting point q or q_3 to this line. A line drawn through q_4

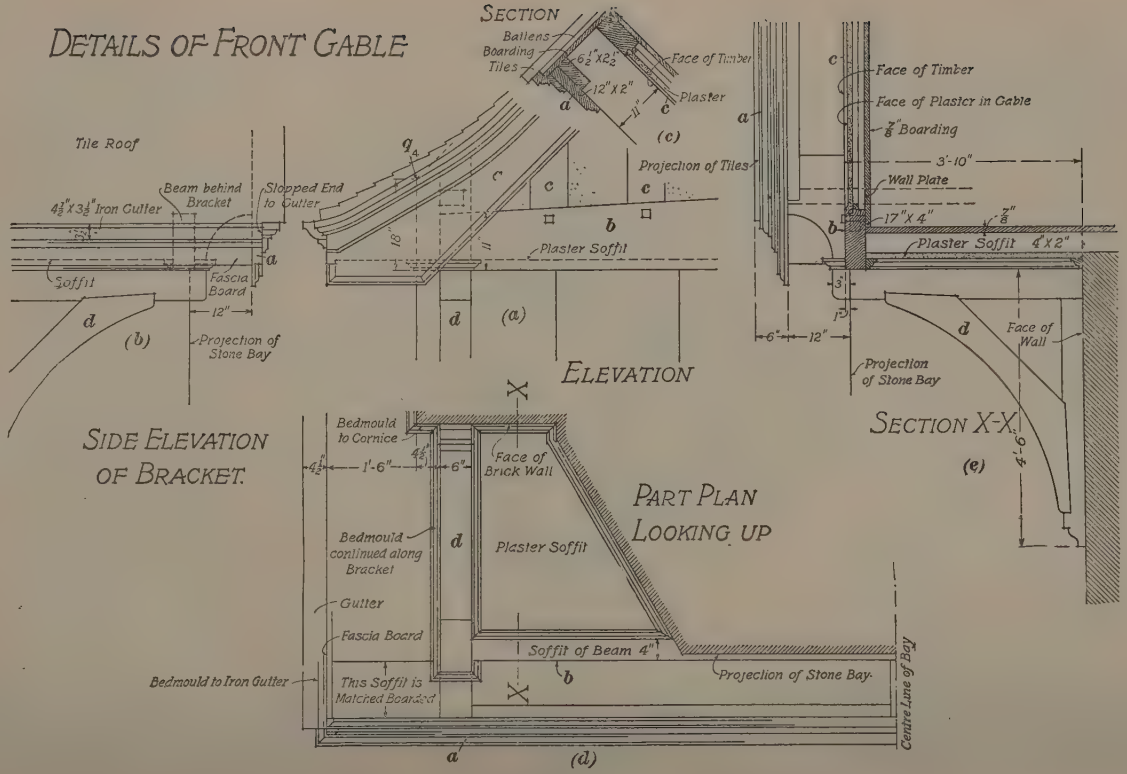

DETAILS OF FRONT GABLE
SECTION
Battens
Boarding
Tiles
6½"X2½"
12"X2"
Face of Timber
Plaster
(c)
Tile Roof
Beam behind Bracket
Sloped End to Gutter
4⅜"X3⅛" Iron Gutter
Soffit
Fascia Board
12"
Projection of Stone Bay
(b)
Projection of Tiles
Plaster Soffit
(a)
ELEVATION
Face of Timber
Face of Plaster in Gable
⅞" Boarding
3'-10"
Wall Plate
17"X 4"
Plaster Soffit 4"X2"
6"
12"
Projection of Stone Bay
Face of Wall
SECTION X-X
(e)
SIDE ELEVATION OF BRACKET
Bedmould to Cornice
1'-6"
6"
Face of Brick Wall
PART PLAN LOOKING UP
Bedmould continued along Bracket
Plaster Soffit
Gutter
Fascia Board
Soffit of Beam 4"
Projection of Stone Bay
Bedmould to Iron Gutter
This Soffit is Matched Boarded
Centre line of Bay
(d)

FIG. 59

at the same inclination as $q\ q_1$ will intersect $q_2\ q_3$ at q_5, which point will determine the position of the front gable ridge. A perspective of this gable with the bay windows of the first floor is shown in Fig. 58, while Fig. 59 gives additional details of the gable. In Fig. 58 the part *a* is called the *barge board* and *b* the *tie-beam;* above *b* are seen the vertical timbers *c* between which are layers of plaster. At *d* are brackets that support the overhanging part of the gable.

193. Fig. 59 contains part of a plan, looking up, and the following elevations and sections: At (*a*) a front elevation of the lower part of the barge board *a*, and the left-hand end of the tie-beam *b* with the lower ends of the timbers *c*. At (*b*) is shown the same portion of the gable in side elevation, and at (*c*) is a section taken through the barge board *a* at right angles to its lower edge. A plan, looking up, of the barge-board bracket, eaves, and plaster soffit is shown at (*d*). In view (*e*) is shown a section taken along line $X\,X$ in view (*d*), looking toward the left-hand bracket *d*. Draw the line representing the under side of the barge board parallel to and at a distance of 16″ from the tile line $q_4\ q_5$. The eaves at q_3 and q_4 are drawn in the same manner as the eaves shown in the section at point *q*, and the minor details may be scaled from the plate. Indicate the moulding along the barge board in the manner shown. The position of the beam is fixed by setting off its lower edge at a distance of 18″ below the point q_4, as shown in Fig. 59 (*a*). At one end this beam is 11″ deep, but at the centre this depth is increased to 17″. The outer side of the bracket is at a distance of $4\frac{1}{2}$″ from the side of the bay, and the bracket has a height over all of 4′ 6″, as shown in Fig. 59 (*e*). Draw the remaining details of this gable in the manner shown on the plate.

194. The dormer that is situated at the centre of the roof is shown in detail in elevation, plan, and section in Fig. 60. These views will be more fully described farther on; at present it is necessary only to fix the position of the dormer and to show its general outlines. As seen from Fig. 60 (*a*), the point q_6 is at a distance of 4′ 8″ + 3′ 6″ = 8′ 2″ above the attic-floor level. The exact position of the latter may be found by

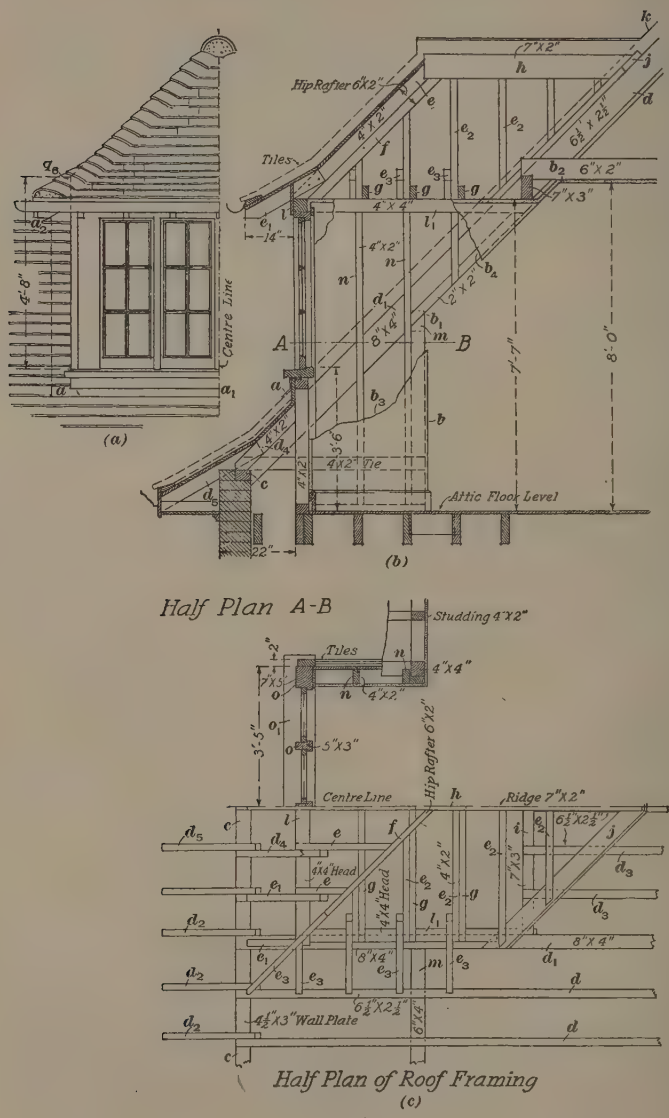

Hip Rafter 6"x2"
Tiles
7"x2"
6½"x2½"
6"x2"
7"x3"
4"x4"
4"x2"
2"x2"
8"x4"
Centre Line
4'-6"
7'-7"
8'-0"
3'-6"
4½"x2" Tie
Attic Floor Level
22"
(a)
(b)
Half Plan A-B
Studding 4"x2"
Tiles
4"x4"
7"x5"
5"x3"
3'-5"
Hip Rafter 6"x2"
Centre Line
Ridge 7"x2"
4"x4" Head
4"x2"
7"x3"
8"x4"
4½"x3" Wall Plate
6"x4"
Half Plan of Roof Framing
(c)

Fig. 60

projecting the corresponding level over from the section to the centre line $A\ B$. The distance of point q_6 from centre line $A\ B$ is found from Fig. 60 (*c*) to be 3′ 7″. Having fixed the position of point q_6, draw a vertical through it to represent the side of the dormer, and also a line inclined at 45° to the horizon to fix the slope of the rafters. By setting off the upper side of the window sill at a distance of 3′ 6″ above the attic-floor level, the position of the window is fixed. It may now be drawn, obtaining any additional dimensions by scaling the drawing plate. In Fig. 60 (*a*) is seen at a and a_1 a *lead apron*, which is a sheet of lead that runs along the dormer for the purpose of making a water-tight joint. In view (*b*) this apron is shown at a to pass under the window sill, and the dotted line $a\ a_2$ in view (*a*) shows that it passes under the tiles.

195. The dormer at the left-hand side of the roof is shown in the centre of the roof in Fig. 61. The ridge line, shown as a dotted line at f on the drawing plate, should be 11′ 6″ above the eaves line at g. The point f is at a distance of 20′ 0″ from the centre line $A\ B$ and the gable projects 12″ beyond the wall of the dormer ; the point f_1 on the eaves line is 4′ 6″ below point f. The dotted line along the lower edge of the side wall shows that the flashing is bent up under the tiles. The chimney is, as seen from Fig. 61, symmetrically placed relative to the ridge. To fix its position, place the point f_2 at a distance of 14′ 6″ from the centre line $A\ B$ and 18″ below the ridge line at f. Draw a vertical and a horizontal line through point f_2 and make the chimney 4′ 6″ wide and 7′ 0″ high. The chimney stack is finished with a stone course at top, 12″ high.

196. The construction of the chimney stack and inglenook at the right-hand side may be ascertained from the several plans and elevations. Place the side $h\ h_1$ of the chimney stack at a distance of $13\frac{1}{2}$″ from the wall and make the part that projects above the dormer 2′ 3″ wide. Between the wall of the dormer and the side $h\ h_1$ of the chimney stack there is a space 18″ wide. The eaves line of the dormer is 4′ 2″ above the eaves line at g_1 and 3′ 0″ below the tops of the ridge tiles. It is noted that there is a lead gutter at the rear of the chimney

stack under the tiles, and lower down at the side of the dormer and chimney stack, where both are of the same width, there is also a flashing. The flashing has here a serrated edge, caused

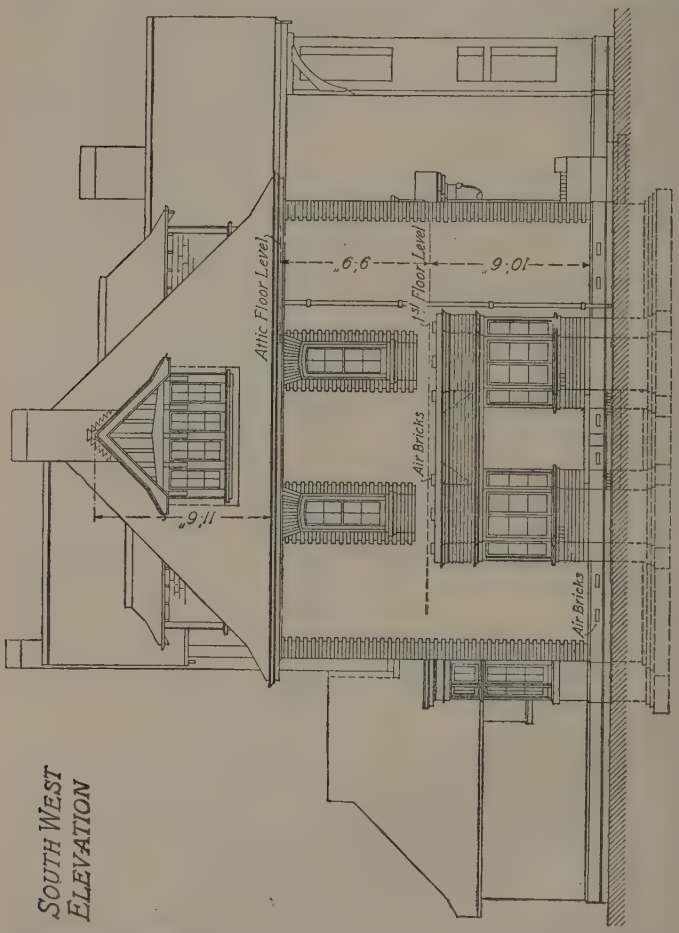
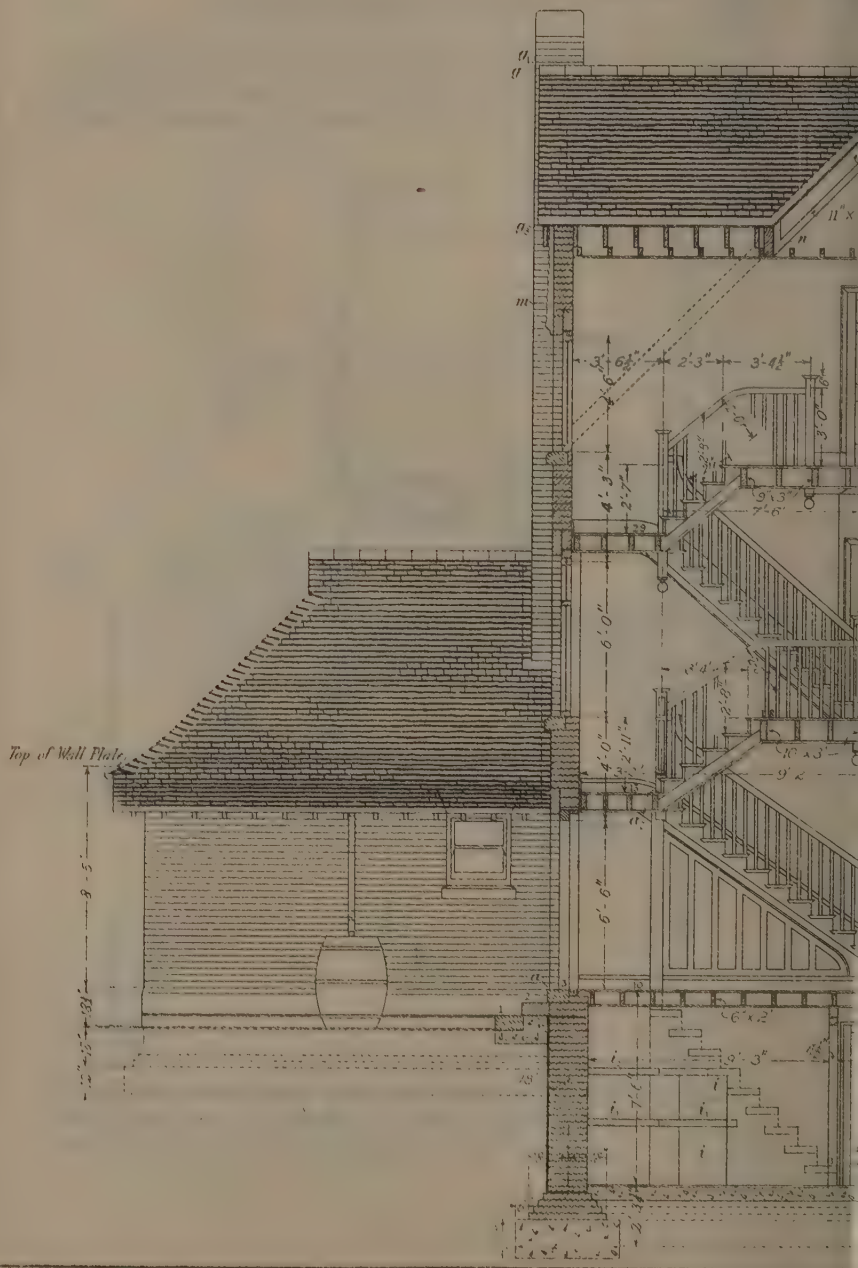


Fig. 61

by incisions being made along one side, the resulting tongues being bent over and inserted at certain places between the brick courses so as to hold the flashing in place.

SECTI



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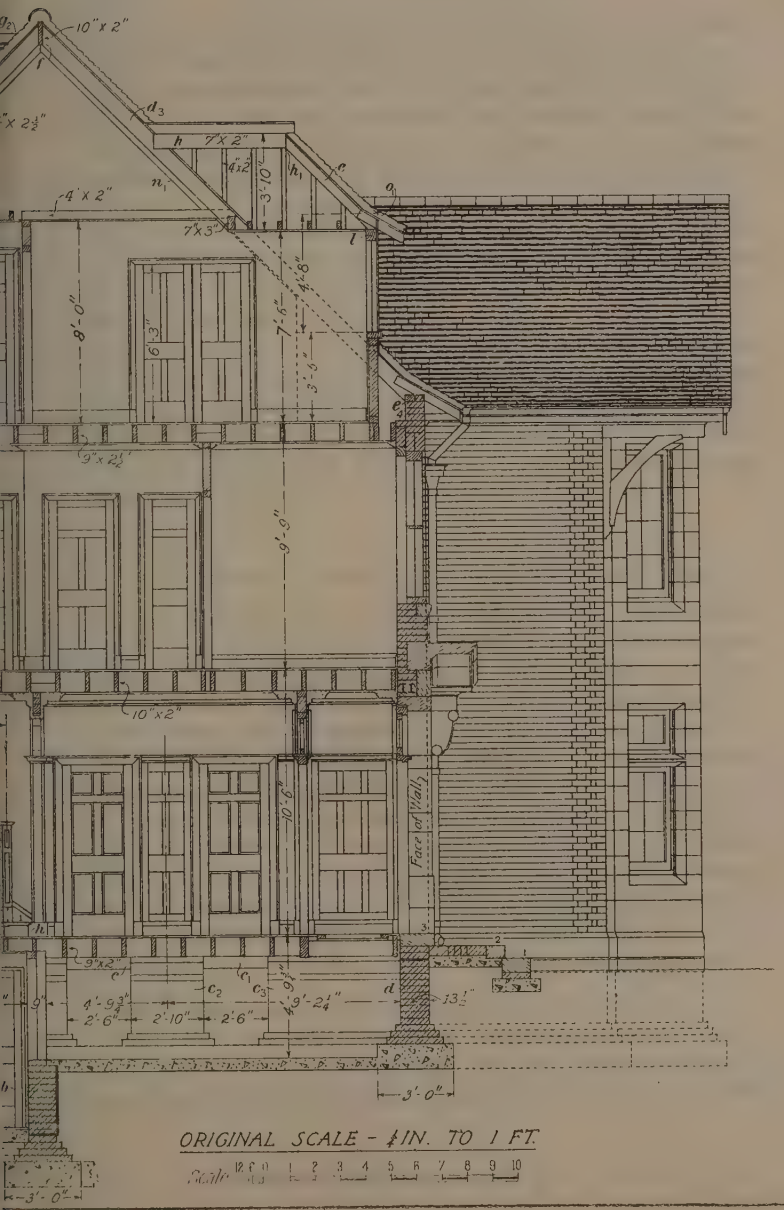
ON A-B



ORIGINAL SCALE - ¼ IN. TO 1 FT.

Scale 12 0 1 2 3 4 5 6 7 8 9 10

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The side h_2 of the large kitchen chimney stack is at a distance of 8′ 3″ from centre line $A\,B$; it is 6′ 9″ wide, and its top is 17′ 0″ above the eaves line at g_1. Now draw the various rain-water pipes, also the foundation and footing courses. The drawing should then be carefully compared with the original and any omission rectified, after which the drawing is inked in. The heavy lines, representing rows of tiles, should be made of a wavy form. This effect may be produced by tipping the drawing pen inwards and outwards while it is sliding along the **T** square. If it should appear difficult to space these lines evenly, they may be drawn in pencil first. The tile rows are spaced a little closer at the eave to indicate the change in slope at this place. All reference letters should be omitted, but the dimensions and names of the various floors should be carefully inserted as they form an important feature of the drawing. After the drawing has been inked in, it should be coloured with thin washes that indicate the various materials.

DRAWING PLATE, TITLE: SECTION A-B

197. This plate shows a **vertical section**, briefly called *section*, on the line $A\,B$, as marked on the ground-floor and first-floor plans. The section presents a view of the interior as it would appear if the building were cut by a vertical plane along the section line $A\,B$ and the left-hand half of the building removed. Such sections are drawn for the purpose of showing the interior arrangement at the vertical plane of section, in the same manner as the ground-floor plan shows the arrangement at the horizontal plane of section. A vertical section shows also the relative positions of the structural parts situated at various levels of the structure. A better idea of the general appearance of the more important parts can therefore be obtained from such sections than by studying the plans and elevations separately.

198. The section $A\,B$ is drawn to a scale of $\frac{1}{4}'' = 1$ ft. Begin by drawing the level of the ground floor at a distance of $2\frac{1}{16}''$ above the lower border line. Set off a point a to fix the position of the face line of the rear wall at a distance of $5\frac{3}{8}''$ from

the left-hand border line, and draw a vertical line of indefinite length through this point. On this line set off the levels of the several floors, the first floor being 10′ 6″ above the ground floor and the attic floor 9′ 9″ above the first floor. Through the points of division draw horizontal lines of indefinite length to indicate the floor levels. Now proceed to draw the principal parts of the section, beginning with the basement. Draw the flooring and joists over the basement by drawing a line parallel to and 1″ to scale below the level of the floor to indicate the thickness of the boards. As the joists under the staircase end of the hall are 6″ deep, draw another line parallel to the floor and at this distance below it.

199. Next draw the foundation wall at the left, making it 18″ thick, and place the base line of the brick footing 8′ $9\frac{3}{4}$″ below the ground-floor level. At a distance of 12′ $7\frac{1}{2}$″ to the right of the rear foundation wall draw the wall at *b*, which corresponds in section to that shown in section *K L*, Fig. 51. It is noticed that this wall is not shown in section above the raised concrete floor ; this is because the section has been taken through the door *j*, shown in Fig. 51. On the drawing plate the door lintel is shown in section. At the right side of this wall the depth of the floor joists has been increased to 9″. These joists are supported either by the lintels *c* and c_1, extending over the openings in the wall, or by the dwarf walls c_2, c_3 into which the lintels *c*, c_1 are embedded. The section of these walls is similar to that shown at section *C D*, Fig. 51. The distance between the concrete floor in this compartment and the floor surface above is 4′ $9\frac{3}{4}$″. The construction of the corbels and footings of the dwarf walls c_2 and c_3 is clearly seen from section *C D*, Fig. 51.

Proceed now to draw the basement wall at *d*. The footings and foundations for this wall are similar to those shown at *b*. Extend the face line of the wall to a point 21′ 0″ above the ground-floor level and complete the drawing of this wall in the manner shown, obtaining additional details for drawing the porch, and the entrance from the plate entitled *Detail of Entrance*.

200. The next step will be to draw the other floors, beginning with the first, in which the joists are $10'' \times 2''$, excepting the trimming joists next the staircase, which are $10'' \times 3''$. Set off the position of the riser under the tread numbered *18* according to the measurements given on the first-floor plan, that is, at a distance of 6′ 6″ from the inside of the rear wall. Fix the position of the corresponding riser to tread *33* at the attic-floor

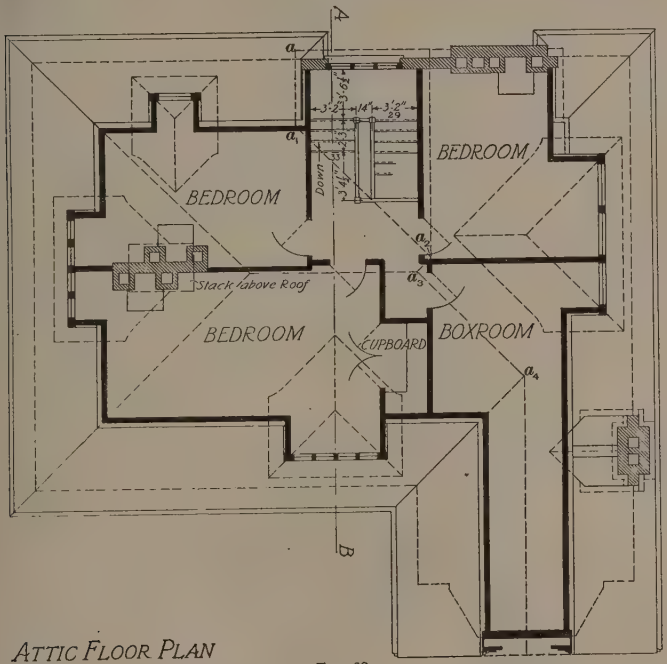


FIG. 62

level, its distance from the rear wall being $2'\ 3'' + 3'\ 6\frac{1}{2}'' = 5'\ 9\frac{1}{2}''$ according to the attic plan, Fig. 62. Now set off the height of the joists in the floors just drawn, this being 10″ for the first and 9″ for the attic floor, and draw lines to indicate the ceiling for the two floors. The placing of the joists is affected to some extent by the position of the staircase, the first joist at the left being placed where the lower side of the string intersects

the ceiling line. The joists are not spaced entirely even, the presence of the heavier joists allowing a wider spacing at that end. The spacing of the drawing should be followed by scaling it.

201. It is customary to set off the stairs after the floors have been drawn, as the stairs often may have to be drawn several times before a satisfactory arrangement can be found. The

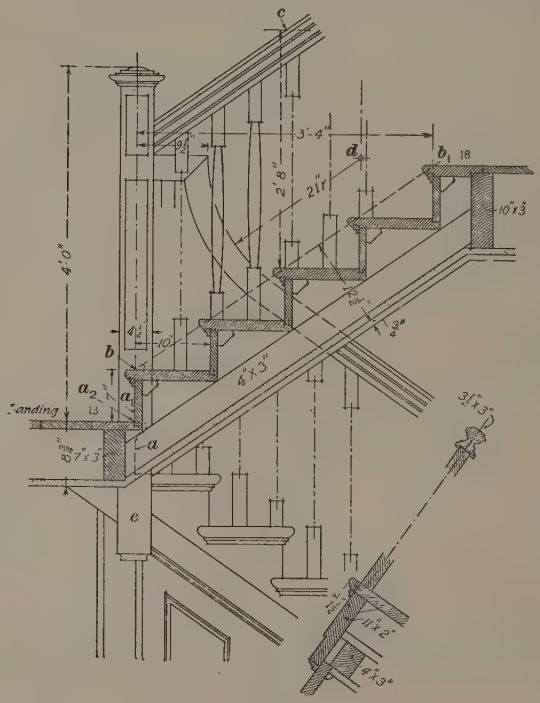


Fig. 63

method followed in setting off the stairs in this drawing is the same as that shown in Fig. 48 and explained in Arts. **150** to **153.** After the required number of divisions have been laid off along the scale *A B*, Fig. 48, the position of the half-way landing is marked off at a_2, the thirteenth division. The positions of the newel posts are next fixed and then a line drawn that represents

the top points of the risers. Additional details of the stairs are given in Fig. 63, from which it will be seen that the outside faces a and a_1 of the last riser in the first flight and the first riser in the next flight, respectively, lie in the same vertical plane. The positions of the treads and risers in the short flight may therefore be fixed by projectors from the first flight and from the line $A\ B$, the points of intersection being the top points of the risers. Through these points draw vertical and horizontal lines which will represent the faces of the risers and top of the treads, respectively. Draw parallels to the latter $1\frac{1}{2}''$ below to represent the lower sides of the treads. Indicate the nosing and back of each tread by short inclined lines, as shown on the plate.

202. Connect the points b and b_1 by a dotted line, as shown in Fig. 63. This short flight must be shown in section, as the section line $A\ B$ in the ground-floor plan passes through this flight. The details of the stairs with the plastered ceiling below are shown in Fig. 63. The flight of stairs from the first floor to the attic floor should be drawn in the same manner as those at the ground floor. The lines of the risers and treads should now be strengthened by heavier pencil lines and the lighter construction lines erased.

Now draw the lower edge of the inclined string parallel to line $b\ b_1$ and at the distance below it shown in Fig. 63. At the foot of the ground-floor stairs the lower end of the moulding under the string is curved, as shown, to a radius of 14″. Draw the wall string line which runs along the wall parallel to the string and a distance of 4″ above the line $b\ b_1$.

203. The upper edge of the hand rail may now be drawn. As seen from Fig. 63, the position of the rail may be fixed by setting off on a riser line, produced, a point c 2′ 8″ above the tread. A cross-section of the hand rail is found in Fig. 63 in the section taken at right angles to the lower at the thickest part of the string. This section is conventional in so far that the tread is shown as parallel to the lower edge. Having drawn this line, draw the curves, which are introduced for the purpose of raising the hand rail at the newels up to the same height as that of the rail on the return flight. There is also a curve at the place where

the hand rail changes its direction to one parallel to the floor. The curve near the newel is shown in detail in Fig. 63. The centre of this curve is found by drawing a vertical line at a distance of $9\frac{1}{2}'' + 21'' = 30\frac{1}{2}''$ from the centre line. Another line parallel to the upper edge of the hand rail and at a distance of 21″ will intersect the vertical at point *d*, which is the required centre of the curve. Describe the latter with a radius of 21″ and continue the curve to a point where it will intersect a horizontal diameter drawn through the centre *c*. This diameter produced forms in this case the upper edge of the horizontal knee at this place. The centre for the curve at the attic floor is found in a similar manner.

204. It is seen from the drawing plate that the upper edge of the horizontal part of the hand rail is 3′ 0″ above the floor line. To find the centre for the curve at these places draw lines parallel to, and a distance of 2′ 0″ from, the inclined and horizontal edge of the hand rail. The point of intersection is the centre for the curved part, which has a radius of 2′ 0″. All the newels are of the same height, except the top one, which is only 3′ 6″ high. Make the width of each newel equal to 4″, and make the newel 4′ 0″ high. It is not necessary to show in detail the cap, as shown in Fig. 63; a square block about $1\frac{1}{2}''$ thick, as shown on the plate, is sufficient for the purpose. Draw the lower side of the hand rail, which is $3\frac{1}{2}''$ thick, but do not indicate the mouldings on it. Indicate also the recessed surfaces on the newels. Details of the balusters are shown in Fig. 63, but it is sufficient to draw them square and of the same thickness throughout; they are spaced as shown in the detail illustration.

205. In Fig. 63 are shown, at the lower edge of the string of those flights through which the plane of the section passes, the plastering and the $\frac{3}{4}''$ soffit moulding that covers the joints between the lathing and plastering at its junction with the face of the string. On the faces of the other flights and landings are shown the face mouldings. On the plate it is sufficient to show simply a section through the plastering. Add pendants to the lower end of the newels; the one shown at *e*, Fig. 63, is without a ball, the close proximity of the wall not leaving sufficient room

for it. Below the first flight of stairs show the panelling or spandrel framing, as indicated on the drawing plate. Finally, draw the basement steps, setting off the inclination of the flight and the positions of the risers in the manner already described. The steps being walled in, as shown in the basement plan, Fig. 51, the risers must be shown by dotted lines, but the treads are drawn in full lines as they protrude through the wall. There is an opening i under these steps into which projects a stone shelf i_1 for the storing of bottles. In the open space at the rear of the steps are two shelves i_1, i_2. There are similar shelves supported by dwarf partitions at the opposite wall, not shown in this view, but seen on the plan, Fig. 51, where the general position of the section line A B is indicated.

206. Proceed now to put in the finish shown on the ground floor, including the cornices, door and window linings, and finishing, which should be drawn to scale measurements taken from the plate. Likewise, draw the door and window openings on the first and the attic floors, as shown. Draw the elevation of the front extension, which is beyond the plane of section, also the rear extension. The principal dimensions of these parts are to be taken from the ground-floor plan and when not given are to be scaled from the drawing plate, *Section A–B*. Show also the front and rear doorsteps. As the brick courses are supposed to have been set off on the rear wall, these lines may be projected to the front and rear extensions so as to indicate the courses shown at these places. Some of the dimensions of the bracket under the front gable are found in Fig. 59, section X X.

207. To set off the positions of the main rafters proceed as follows: From the lower corner of the 3″ wooden plate at e_4 draw a line e_4 f inclined to the horizon at an angle of 45°, and draw a similar line from a point opposite to e on the rear wall. These lines will meet at f at a height of 15′ 0″ above the attic floor line. As the rafters are $6\frac{1}{2}$″ deep, draw other parallel lines at this distance from those just drawn. Extend the outer face line of the rear wall to a point g, 35′ 6″ above the ground-floor level, and through this point draw a horizontal, not shown, to represent the upper side of the ridge in the rear gable. At a

distance of 2″, to scale, above this line draw the line $g_1 g_2$, indicating the upper sides of the curved tiles. The gable line $g_1 g_3$ is at a distance of 8″ from the face of the wall. It is seen that the gabled extension over the staircase is intersected at one side near the eaves by the section line $A B$. Consequently, as indicated on the drawing plate, the rafters of this roof will be shown in section and likewise the joists that support the ceiling over the staircase. The distance between these joists and the attic floor is 8′ 1″, allowing 1″ for the plastered ceiling of the attic.

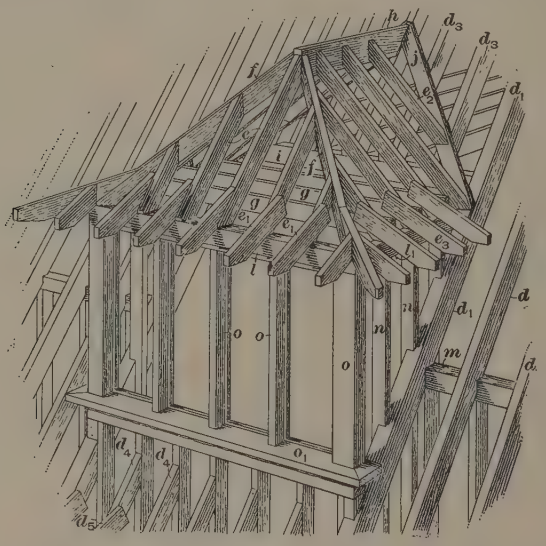


Fig. 64

208. Continuing the drawing of the roof lines, rafters, and ceiling joists, proceed to add the dormer at the right of the attic, details of which are found in views (*b*) and (*c*), Fig. 60, where the dormer is also shown in elevation at (*a*). Fig. 64 is a perspective view of the framing in the dormer in which similar reference letters to those used in Fig. 60 represent similar parts. In Fig. 60 (*b*) is shown a section taken along the centre line of view (*a*); view (*c*) shows below its centre line a half-plan

of the dormer and above the centre line a half-plan taken along line *A B*, view (*b*). The latter view corresponds in general with the section of the dormer shown on the drawing plate, except that in the latter view the opposite wall is shown, which here joins the main attic wall. In view (*b*) the dormer partition stops at the angle *b*, where it joins the low partition running at right angles under the roof slope. From point b_1 to b_2 the angle follows the slope of the roof until at b_2 it joins the ceiling. The plastering between the lines b_3 and b_4 has been broken away, so as to show the studding underneath. The ceiling to the left of line b_4 has also been removed for the same purpose.

209. In views (*b*) and (*c*) the wooden plate on which the rafters rest is shown at *c* and the main rafters at *d*, to which sprockets d_2 are attached. At each side of the dormer are the $8'' \times 4''$ trimming rafters d_1. At the top of the dormer in the front slope are the rafters *e* with sprockets e_1, and at the side the rafters e_2 with their sprockets e_3. To the hip rafter *f* are fastened the upper ends of the rafters *e* and e_2 and below the latter are seen the joists *g*, which in the plan seem to run parallel to them, but, as seen from the section, really run in a horizontal direction. At the top of the dormer studding *n* rest the heads *l* and l_1, one end of the latter being halved and fitted on to the rafter d_1. Forming the front slope of the dormer roof are the rafters *e* with sprockets e_1 ; one end of these rafters rests on the head *l* and the other is fastened to the hip rafter *f*. The rafters e_2 with sprockets e_3 rest on the head l_1, fastened either to the ridge *h* or to the hip rafter *f*.

210. Where the dormer joins the main roof is a sole *j*, which runs parallel to the hip *f* and lies flat on the rafters d_3 to which it is fastened. The rafters d_3 stop at the trimmer *i* on which they rest. Some of the rafters e_2 rest on the sole *j*, as shown in views (*b*) and (*c*). At *m* is another head that rests on the studding along the side of the roof. There is a series of short rafters d_4 below the dormer window, which in the half-plan in view (*c*) are partly hidden by the sprockets e_1 above them. One of the latter, near the centre line, has been broken away so as to show the rafter d_4 with its sprocket d_5.

In the half-plan on $A\ B$, Fig. 60 (c), are seen the studs n that support the head l_1; at o are the window frame and mullion on which rests the head l.

211. Begin the dormer on the plate by drawing the face of the frame, shown at o in Fig. 60 (c), at a distance of 22″ from the outer face of the brick wall. Make the height of this frame 7′ 7″ and draw through its upper end a horizontal line to fix the position of the ceiling in the dormer and of the head l for the rafter. Continue the face line of the frame to a point o_1 at a distance of 8′ 2″ above the attic floor, and from this point draw a line inclined at an angle of 45° to the horizon to indicate the position of the tiles. At a point 3′ 10″ above the dormer ceiling draw another horizontal for the upper side of the dormer ridge h and continue this line until it intersects the rafter d_3; make this ridge 7″ deep. Complete the head l by making it 4″ square and draw from its inner edge the under side of the rafter e at an angle of 45° to the horizon and intersecting the ridge at h_1. Draw the upper side of the rafter which is 4″ deep and add the sprocket, its position being fixed by drawing its under side through the exterior edge of the head at an inclination of 30° to the horizon. It should project a distance of 14″ beyond the face of the head, as shown in Fig. 60 (b).

212. Now draw the boarding supported by the rafters and sprockets and also the curved tiles over the ridge. Add the side rafters indicated by vertical lines, the spacing being 14″, and also draw the ceiling joists, shown in section, and add the joist that extends from the rear partition toward the main rafter. The framework of the main roof may now be completed. At n is shown the section of a trimming rafter indicated in the plan, Fig. 62, by the dotted line $a_1\ a_2$. This rafter has a section of 11″ × 3″, but, being cut at an angle by the section plane, it appears larger. A similar rafter n_1 is seen at the other side, but this is situated farther in the rear, being indicated in Fig. 62 by the line $a_3\ a_4$. Draw now the 10″ × 2″ ridge, the outer boarding, and the profile of the tiles. Then show the section of the boarding beginning at g_3, also the rafters and joists shown in section beneath it. At m are shown some of the suspended

tiles on the gable; these are shown in the perspective, Fig. 37. Below point g_3 is shown a cross-section of the gable rafter, which runs along the overhanging part of the gable roof. The tiles on the various roof surfaces may be drawn as on the plate.

Draw the chimney by scale measurements from the drawing plate and complete other parts of the drawing, such as window and door sills, lintels, steps, gutters, and rain-water pipes. Then the drawing should be carefully inked in, and the walls and cross-sections of the timbers neatly sectioned, as shown. Insert now the dimension lines and figures, but omit the reference letters.

DRAWING PLATE, TITLE: DETAIL OF BAY WINDOW

213. The bay window of which the details are to be shown on this plate is that shown at the rear of the drawing-room in the ground-floor plan. It is also shown in the perspective view, Fig. 37. As it is desirable that one of the views on this plate shall be drawn without any detailed instructions, there will be no sample drawing plate furnished to serve as a guide in drawing this particular view. In place of this, a reduced copy of the plate is given in Fig. 65, which will provide the necessary data for drawing the view and also give a general idea of the arrangement of the views. All the views shown in Fig. 65 are also to be drawn on the plate. In this illustration are given: a section taken along the centre line of the window, an enlarged detail of the transom, and a half-plan of the window taken along a line below the transom. It is required to draw one-half of the external elevation, using a scale of $1'' = 1$ ft.

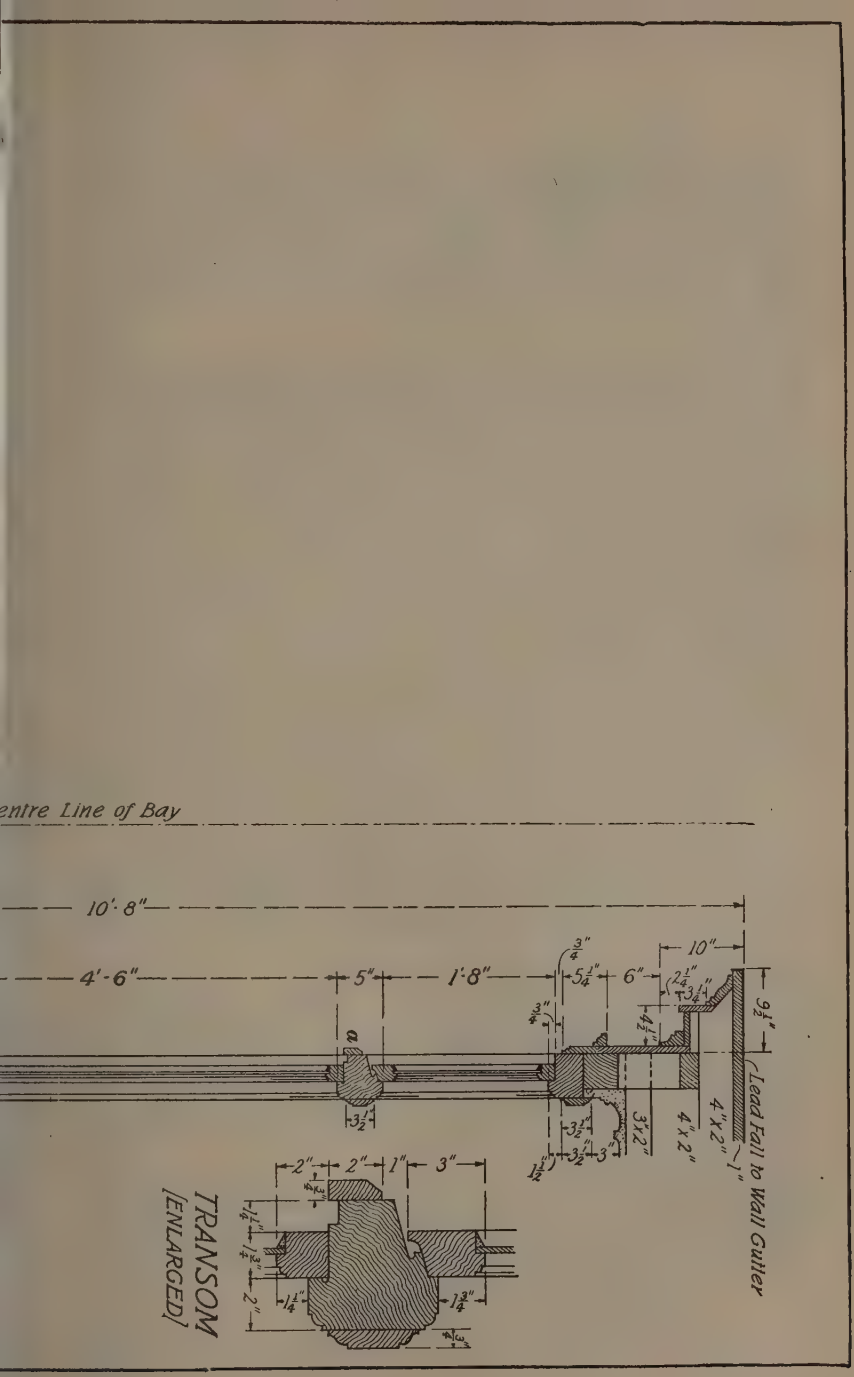
214. Begin the plate by drawing the ground-floor level at a distance of $5\frac{1}{4}''$ above the lower border line; also a vertical line for the face of the wall in the section at a distance of $3''$ from the right-hand border line. The external face of the lower sash in the enlarged detail of the transom may be drawn at a distance of $1\frac{5}{16}''$ from the right-hand border line, and the top of the sash $5''$ below the upper border line. The face of the wall in the plan is to be placed $3''$ above the lower border line.

To serve as the centre line for this plan, and also for the half-elevation to be drawn, erect a vertical at a distance of $5\frac{1}{4}''$ from the right-hand border line. By means of the plan and the section, it is possible to draw the elevation.

215. It is best to draw the section first, according to the dimensions given. The transom has been shown in a separate detail view, as this part is too small in the section to allow the insertion of the necessary dimensions. At *a* is a drip mould that is fastened to the curved face of the transom, continuing along it until it meets the brick wall at the side.

216. When beginning the plan, set off first points *b* and *c* according to the dimensions given. Then, considering these points as the ends of a chord *b c*, erect a line at right angles to it at its centre. This line will pass through the centre of the arc *b c* and its points of intersection with the vertical centre line of the bay will give the exact position of the arc centre. This arc may now be described. From the points *c* set off along the centre line the dimensions necessary for describing the other arcs concentric to arc *b c*. The dimensions of the sashes and sill are found in the transom detail. The centre of the face of the frame *d* is at a distance of $1\frac{1}{4}''$ from point *b*. This face is of the same width as the corresponding faces of the mullions and their centre lines are equal distances apart. Therefore, on dividing the arc *b c* into 5 equal parts, the space *c e* will be 1 part wide, *e f* and *f g* each 2 parts wide. Through the centre points of these faces draw radial lines toward the centre of the arc. It is to be noted that the sides of each mullion and of the adjoining sashes are to be parallel to the centre line of the mullion. The joints in the stone sill are directly under the centre lines of the mullion, and these joints are to be shown in the elevation.

217. In drawing the elevation, there are several points that require particular attention. Among these may be mentioned the construction of the lines of intersection between the various moulds and the brick wall. For instance, the line of intersection $b\ b_1$ of the stone sill is 3″ long instead of 2″, as shown in


entre Line of Bay
10'·8"
4'·6"
5"
1'·8"
10"
Lead Fall to Wall Gutter
TRANSOM
(ENLARGED)

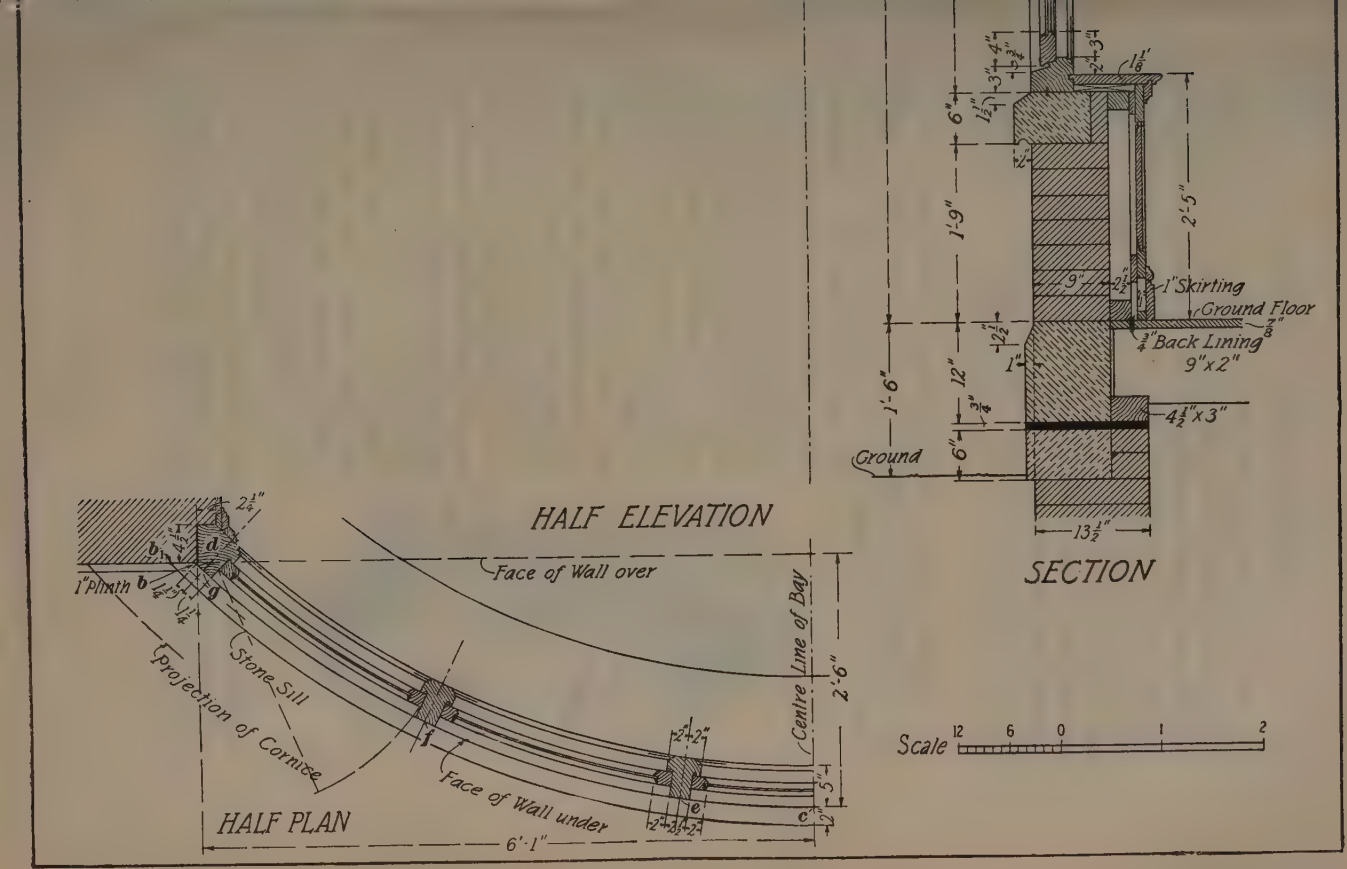
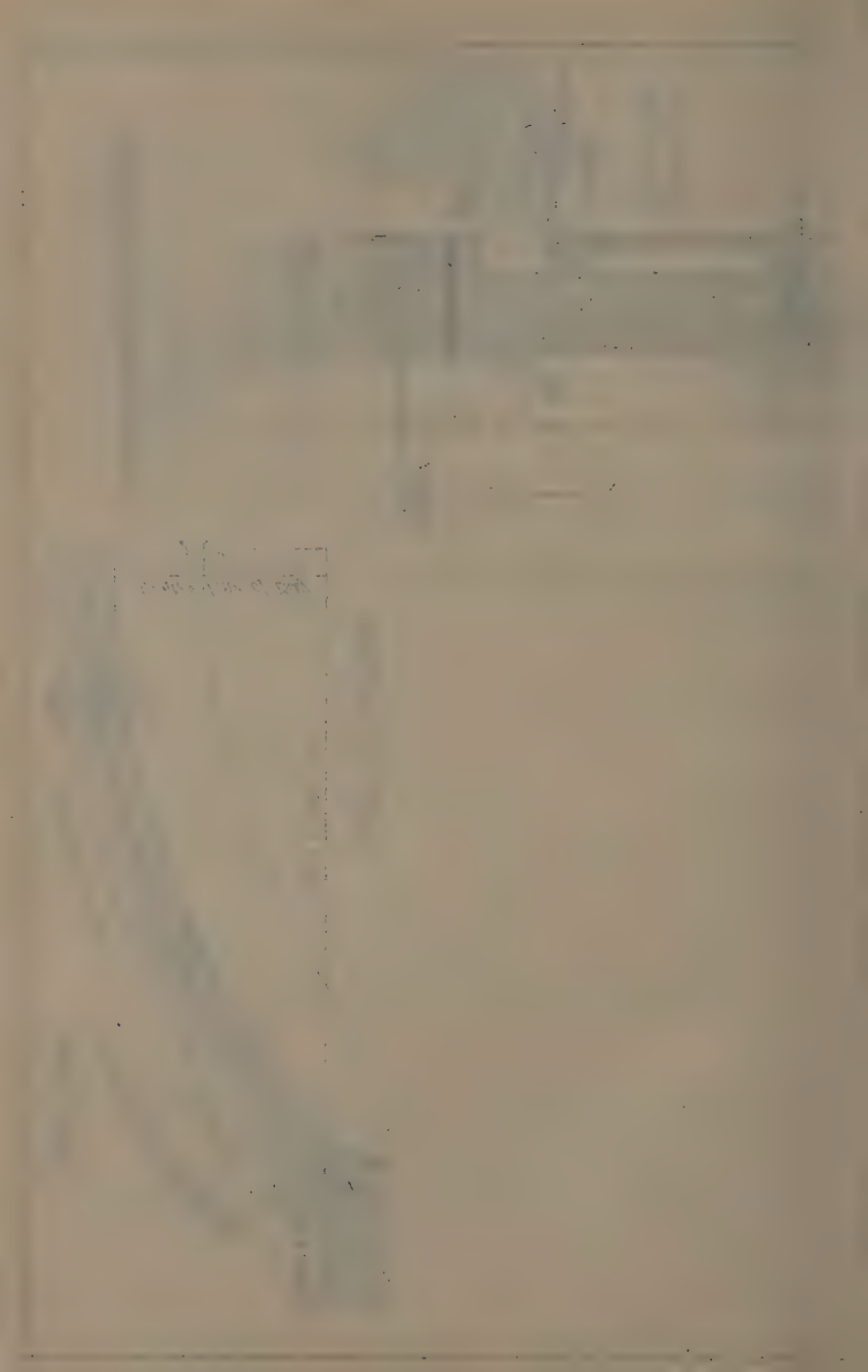

HALF ELEVATION
SECTION
HALF PLAN
Face of Wall over
Face of Wall under
Centre Line of Bay
Projection of Cornice
Stone Sill
1" Plinth
1" Skirting
Ground Floor
3/4" Back Lining
9"x2"
4 1/2"x3"
Ground
Scale
12
6
0
1
2
6'-1"
2'-6"
2'-5"
1'-9"
1'-6"
13 1/2"

Fig. 65



the section. The profiles of the other moulds will be enlarged in depth in the same manner when their intersections with the brick wall are shown. The true outlines of these planes of intersections can be found only by describing an arc in the plan at the required distance from arc $c\,d$ and finding its point of intersection with the face of the wall, as at b_1 for the sill. This point is then projected to the elevation, where it will intersect a projector drawn from the point in the section corresponding to the arc in the plan. The point of intersection will be the required point in the elevation.

218. Some difficulty may be found in seeing mentally the plane of intersection between the sill and the wall face. It is noticed from the section that the upper side of the sill is bevelled. This bevelled surface is continued until it meets the wall face, where it is intersected by a surface chiselled in the stone at such an angle that it will lie in the same plane as the face of the wall. This may be better understood by examining Fig. 66, which is a perspective view of one corner of the bay. It is seen from this that the line at g represents the end of the bevelled surface and that this line also lies in the plane of the wall face. It is understood that the stone sill projects for some distance into the wall. This view shows also the plinth course and parts of the window frame and sash. Some care is required in drawing the lines of intersection between the bevelled surfaces on the window frame.

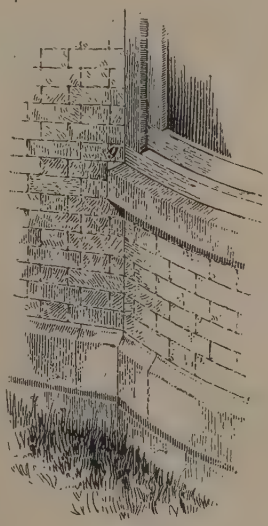


Fig. 66

The brick courses should be indicated by horizontal lines across the elevation, beginning at a distance of $\frac{1}{2}''$ from the left-hand border line, but the separate bricks should not be

shown. Indicate also the ground line at the foot of the elevation, as in the section. The plate should be inked in and sectioned. Place the title at a suitable place at the top of the plate and insert the other lettering as shown.

DRAWING PLATE, TITLE: STEEL STANCHION AND CONNECTIONS

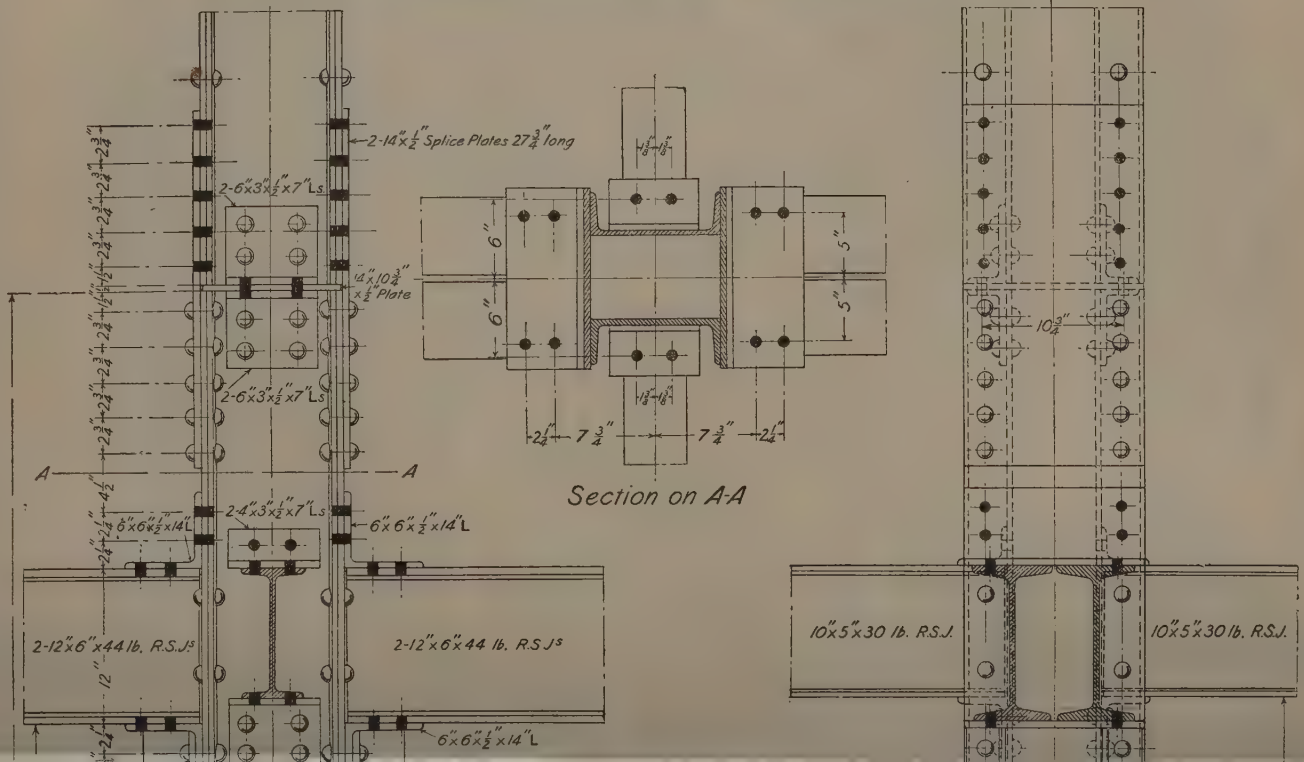
219. As an example of steel construction, the shop, or working, drawing of a built-up steel stanchion has been selected, by means of which the terms used and the methods employed in the execution of this class of drawings will be shown.

The scale to be used is $1\frac{1}{2}'' = 1$ ft. This is the usual scale to which working drawings of this class are made.

220. Before proceeding with the drawing, it is necessary to give the terms used with reference to this plate and also explain the purposes of the several parts. From the perspective view, Fig. 67, it is seen that the stanchion consists of two channels *a*, *a* placed back to back and tied together by **flange plates** *b*, *b*. The stanchion is supported on a steel bedplate, to which it is attached by side plates *c*, *c*, called **gussets,** or **gusset plates,** the angles *d*, termed **gusset angles,** serving as the means by which the gussets are connected to the bedplate. Each channel, for further security, is tied to the bedplate by angles *e*, called **base angles,** one of which is shown in the illustration.

The stanchion supports two pairs of **floorbeams,** or **joists,** of which *f*, *f* are longitudinal, and *g*, *g* transverse, joists. Each pair of the longitudinal beams is supported on an angle bracket *h*, which is further stiffened by angles *i*, *i* placed back to back. A **packing piece** *j* is placed between the flange plate and the lower part of the angles *i*, *i*. The purpose of this piece is to give the outer angles support along the whole length and to allow them to be riveted to the stanchion. The floorbeams *f* are tied at their upper flanges to the stanchion by means of angles *k*. Each transverse floorbeam *g* rests on a bracket *l*, which is without any stiffener, the load on this joist not being heavy enough to require it. Another angle *n* ties the top of this joist

STEEL STANCHION & CONNECTIONS.



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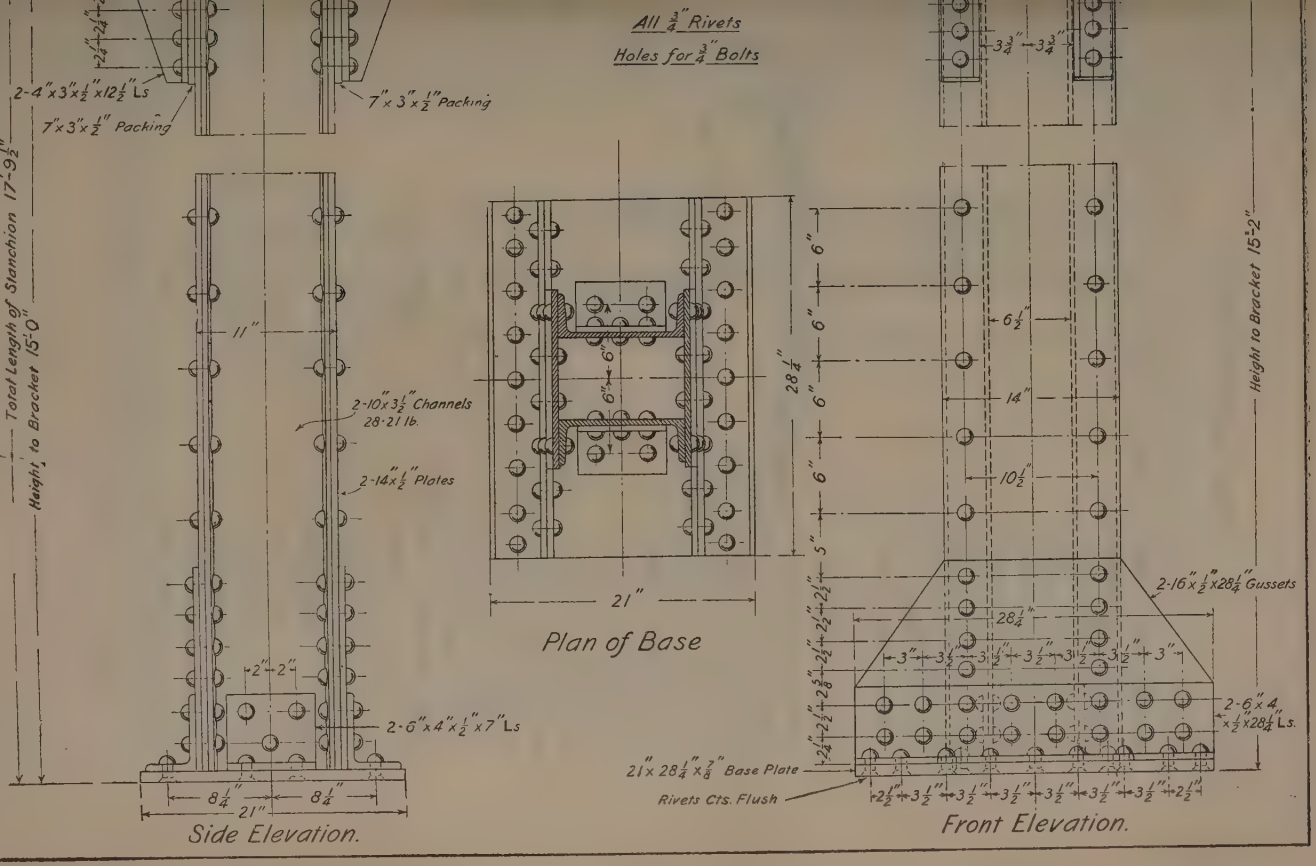

to the stanchion. The latter is made in sections so as to facilitate its transportation to the place of erection. Only the lower section is shown on the plate together with the **splice,** or **joint.** The lower section is spliced to the adjoining one by the vertical **splice plates** *o*, *o*, a horizontal **splice plate** *p*, and angles *q*.

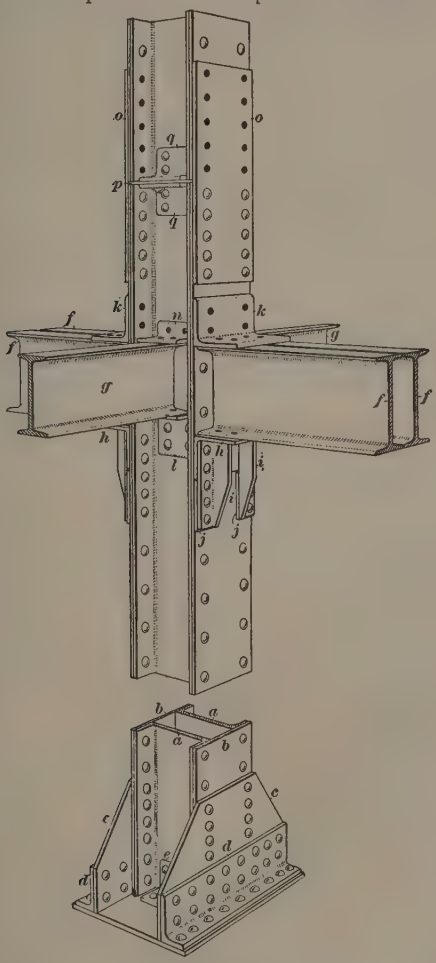

FIG. 67

221. The distance between the centre of two rivets is called their **pitch,** commonly designated on drawings by the word **space.** Attention is called to the fact that at some places the rivets are omitted and the rivet holes shown black. This indicates that the rivets belonging to these holes are to be driven during erection instead of in the shop; they are therefore known as **field rivets.** When a side view is made of these holes they are indicated by a blackened rectangle. Holes for field rivets are shown in the upper part of the splice, also at the ends of the joists where they are to be fastened to the stanchion. According to

the rules of drawing, their positions should be shown by dotted lines, but the conventionalism of blackening in is resorted to as being a better means of calling the attention of the workman to the fact that the rivets destined for these holes are field rivets. This common usage is departed from only in the case where the parts through which the field rivets pass are hidden behind some other parts of the structure. Thus, referring to the side elevation of the stanchion on the plate, field rivets are shown passing through the horizontal splice plate and the two angles, and as neither the plate nor the angles are hidden, their positions are indicated by blackened rectangles. In the elevation, however, the horizontal plate at the splice, and the angles, are hidden behind the vertical splice plate and the flanges of the channels ; consequently, the field-rivet positions are shown in this view by dotted lines.

222. It would evidently be impossible to show the whole length of the stanchion, and at the same time to a scale large enough to make the details distinct, without requiring an unnecessarily large sheet. To avoid this, the stanchion elevation has been divided into two sections and some parts broken away as being simply duplicates of the parts remaining. The method of indicating where breaks occur consists in drawing a dash-and-dot line along the adjoining parts of the break. The part removed contains a number of rivets which are spaced similarly to those in the adjoining parts that remain ; it would therefore be superfluous to show them.

223. The dimensions of the various angles, channels, and beams used in constructing the stanchion are not given in detail, they being unnecessary on a working drawing. All that is required is to give the sizes. The note "$2 - 12'' \times 6'' \times 44$ lb. R.S.J^s." on the left-hand part of the joist, shown in the side elevation, means that the part indicated is made up of two **I** beams, 12″ deep and 6″ wide, weighing 44 pounds per foot of length. The letters *R.S.J^s.* indicate *Rolled Steel Joists*. These joists and angles are rolled in lengths of about 15 to 20 feet and can afterwards be cut into smaller lengths, to one of which the length "14″" refers in the note "$6'' \times 6'' \times \frac{1}{2}'' \times 14''$ **L**"

found below the **I** beam just mentioned. This note states that the bracket is made of a 6″ angle, $\frac{1}{2}$″ thick.

The packing pieces are also cut from long bars varying in width and thickness according to the space to be filled. For instance, the note "7″ × 3″ × $\frac{1}{2}$″ Packing" found below the **I** beam referred to means that the packing plate is to be cut from a plate 3″ wide by $\frac{1}{2}$″ thick, and to a length of 7″.

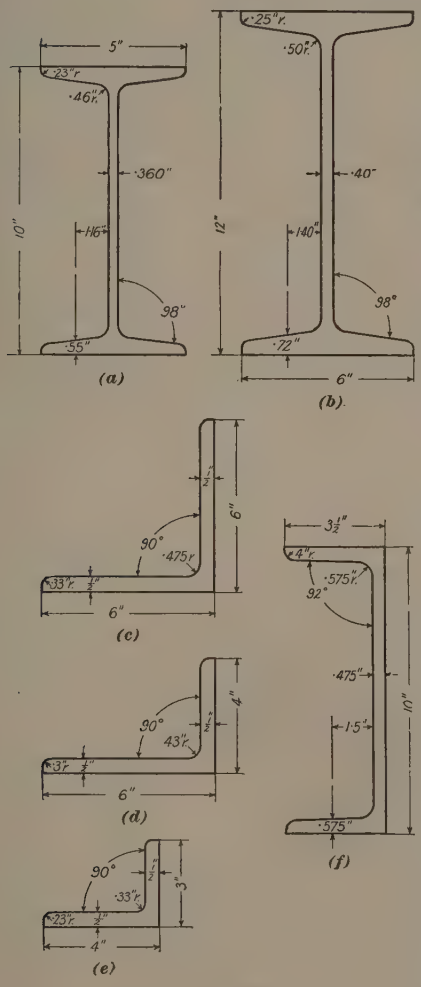

FIG. 68

224. As an aid in drawing the various forms of **I** beams, channels, and angles shown on the plate, several sections, fully dimensioned, are given in Fig. 68. The dimensions given are according to the standards recommended by the Engineering Standards Committee. The section of the 10″ **I** beam is given in Fig. 68 (*a*), of the 12″ **I** beam in (*b*), of the 6″ × 6″ angle in (*c*), of the 6″ × 4″ angle in (*d*), of the 4″ × 3″ angle in (*e*), and of the 10″ × 3½″ channel in (*f*).

In Fig. 68 most of the dimensions are given in decimals or as they appear in the catalogue of the rolling mill. Since it is practically impossible to set off these decimal dimensions to a scale of $1\frac{1}{2}'' = 1$ ft., it is recommended to use the nearest sixteenths of an inch, taking $\cdot 23 = \frac{1}{4}$, $\cdot 33 = \frac{5}{16}$, $\cdot 36 = \frac{3}{8}$, $\cdot 40 = \frac{3}{8}$, $\cdot 46 = \frac{7}{16}$, $\cdot 475 = \frac{1}{2}$, $\cdot 575 = \frac{9}{16}$, $\cdot 72 = \frac{3}{4}''$.

All rivets in this stanchion are $\frac{3}{4}''$ diameter. The holes for the rivets are generally punched $\frac{1}{16}''$ larger than the rivet shank, the size of the rivet being indicated by the diameter of the shank *before* the rivet is driven. All $\frac{3}{4}''$ rivets require holes $\frac{13}{16}''$ in diameter. The rivets when driven fill these holes; consequently the *driven* size of a rivet = nominal size + $\frac{1}{16}''$.

225. To draw the plate begin by drawing the centre lines of the two elevations, of which the one on the left side is a side elevation, the other a front elevation. The centre line for the first view should be $2\frac{3}{4}''$ from the left-hand border line and the centre line for the front elevation $2\frac{11}{16}''$ from the right-hand border line. Draw also a vertical centre line for the section *A A* $6\frac{1}{2}''$ from the left-hand border line with a horizontal centre line $3\frac{1}{2}''$ from the upper border line. Place the vertical centre line of the base plan $6\frac{5}{16}''$ from the left-hand border line and its horizontal centre line $4\frac{3}{4}''$ above the lower border line.

At this point, it is necessary to note that all symmetrical drawings must be drawn about centre lines, and each symmetrical part of the main object must also have its own centre line. In the works, all setting out and drilling is necessarily done from centres, and this matter cannot be too much emphasized.

226. The first view to be drawn is that indicated as a *Plan of Base*. This view is a plan taken along an imaginary plane above the base and drawn as it would appear looking down on the top of the base. Set off on each side of the vertical centre line a distance equal to 5″, one-half the depth of the channel, and draw the two flange plates 14″ wide and $\frac{1}{2}''$ thick. On each side of the other centre line draw horizontal lines at a distance of $3\frac{1}{4}''$, representing the backs of the channels, then draw in the channels from the dimensions given in Fig. 68, thus completing the section through the body of the stanchion. Still working

from the centre lines, measure off on each side of the respective centre line distances equal to $14\frac{1}{8}''$ and $10\frac{1}{2}''$, indicating the size of the base plate and draw its rectangular outline. Draw the dimension lines and write in the dimensions. It is not advisable to postpone the insertion of the dimensions until the whole drawing is complete, as, inevitably, some dimensions will be omitted. As soon as a size is determined it is better to write it down at once than to rely on the memory later on.

Next mark off a thickness of $\frac{1}{2}''$ for the gusset plate on each side of the flange plates, and also the thickness of the long flange of the $6'' \times 4'' \times \frac{1}{2}''$ gusset angles, and the width of short flange. Draw the gussets and angles the full length of the base plate, and also insert the $6'' \times 4'' \times \frac{1}{2}'' \times 7''$ base angles riveted to the channel webs. Mark off the positions of the centre lines of the rows of rivets, seen on the base plate, the positions of these centre lines being found in the side elevation. Then indicate by cross-lines the centres of the rivets, the positions of which are found at the base of the front elevation. Finally, mark off by crossed centre lines the positions of the other rivet centres, the required dimensions being found in the two elevations.

227. From the base plan the bases of the two elevations may be drawn, the base line in each view to be placed $\frac{3}{4}''$ above the lower border line. Considering the side elevation first, set off a distance of $5''$ on each side of the centre line, which distance is equal to one-half the channel depth, and draw vertical lines of indefinite length indicating the channel. Set off the thickness of $\frac{1}{2}''$ indicating the thickness of the flange plates and draw lines parallel to the channel. Draw the base plate $\frac{7}{8}''$ thick and $21''$ wide, then the gusset plate and angles, the height of the gusset plate being $16''$, as seen from the note at the foot of the front elevation. Finally, insert the base angles. Proceeding for a while with the front elevation, draw the vertical outlines of the flange plate $7''$ on each side of the centre line. Mark off the distance between the channels $3\frac{1}{4}''$ each side of the centre line and indicate by dotted lines the thickness of the web and width of flanges. The vertical dimensions of the base plate, gusset angles, and gusset plate may now be projected across from the

side elevations. After setting off the length of the base plate, the lower part of this view can easily be finished. It will be noticed that the gusset plates are cut away from the top corners of the gusset angles to the intersection with the flange plates of the stanchion. This improves the appearance, and as the portion of plate sheared off is unnecessary for strength, it is usual to treat it in this way. Were the plate left square, there would be also an unsupported corner that probably would be bent in transit. Set off the centres of rivets according to the dimensions given in the plan, and draw their centre lines. The note " Rivets Cts. Flush " seen below the base indicates that the rivets are to be countersunk flush with the lower surface of the base plate.

228. Next draw in the floor joists shown in both elevations, the general dimensions of the joists being given in Fig. 68. In the side elevation a $12'' \times 6''$ standard **I** beam is shown in elevation on each side of the stanchion, while a $10'' \times 5''$ **I** beam, abutting against the web of the channel, is shown in section. Each of the brackets supporting these joists is composed in the main of a $6'' \times 6'' \times \frac{1}{2}''$ **L** braced by another angle $4'' \times 3'' \times \frac{1}{2}'' \times 12\frac{1}{2}''$ riveted to it and to the flange of the stanchion. Between the vertical angles and the stanchion are packing pieces $7'' \times 3'' \times \frac{1}{2}''$. The rivets should next be drawn and the size of each piece written in. Insert now the bracket for the $10''$ **I** beam. Angles are shown attaching the tops of the beams to the stanchion, which construction gives a much greater stiffness to the connection. These angles should now be drawn and the positions of the bolts and field rivets indicated. After projecting the details of these connections to the front elevation, the sizes and description of each separate part should be written in with the necessary arrows for indicating the parts referred to.

229. The plan of the joist connections with a section of the stanchion taken on line *A A* in the side elevation may now be shown on the centre lines previously set out.

Commence by indicating the cross-section of the stanchion, then draw the beams as they appear in the plan and add the connecting angles with the positions of the holes for field rivets,

indicated by black circles. The rules for spacing the holes in the flanges of **I** beams are as follows: The holes for a beam 6″ wide are placed $1\frac{3}{4}$″ on each side of the centre line, and for a 5″ beam, $1\frac{3}{8}$″ on each side. This is a universal rule, unless special circumstances demand a slight variation.

230. The splice or joint above section line *A A* in the side elevation will be considered next. In this joint the side plates are shown riveted to the lower section of the stanchion while the holes in the upper halves of the plates are left open for the field rivets.

First, set off the rivet centres, working from the top of one of the 12″ × 6″ joists, as shown in the side elevation. Follow up the chain of dimensions given until the thickness of the joint plate, $\frac{1}{2}$″, is reached; draw this in, and set off the remaining centres of holes in the upper length. Transfer these by projection across to the front elevation, and the intersection of the centre lines with the line of rivets, already determined at the base, $5\frac{1}{4}$″ on each side of centre line of stanchion, fixes their positions in this elevation. The drawing in of the pairs of angles at the joint completes the general outlines of the part.

231. It should be a rule, when detailing constructional work, to work in fine faint lines, figuring in dimensions and descriptive notes as the work proceeds. When the whole piece is outlined, the lines required may be made stronger, dotted lines inserted, and the work finished off.

The riveting, at first, should only be indicated by centre lines; in many offices this is all that is shown, but in this example the heads are properly drawn in and their shape indicated by the shade line. The sectional parts of a drawing are often coloured in some dark tint, violet for preference, or they may be section-lined as shown.

Dimensions representing the length of the stanchion should be added, and also those indicating the levels of the various floor joists. These last dimensions are the most important part of the whole drawing. If they are not correct, the whole stanchion will be useless for its purpose, unless it admits of alteration after manufacture: a most unsatisfactory proceeding.

PHOTO-COPYING OF DRAWINGS

BLUEPRINTING

232. Ferro-Prussiate Paper.—Blueprinting is the name of a process by which any number of copies may be obtained from a single tracing. It is based on the properties that certain chemicals possess of changing colour on exposure to the light; and its operation consists of subjecting to strong sunlight a sheet of prepared paper, which is covered by the tracing and held in close contact by means of a sheet of heavy glass. The light passing through the transparent tracing causes the paper to turn blue over all its surface, except where protected by the opaque lines of the drawing, and thereby produces a print that duplicates the original drawing so far as lines and measurements are concerned, but in white lines on a blue ground.

233. Although it is usually much more economical to purchase ferro-prussiate, generally called blueprint paper, ready for use, its preparation is very simple, and in an emergency the paper may be prepared as follows: In a dark-coloured or opaque bottle dissolve 2 ounces of citrate of iron and ammonia in 8 ounces of water; and in a similar bottle dissolve $1\frac{1}{4}$ ounces of ferri-cyanide of potash in 8 ounces of water. These solutions should be mixed in equal portions immediately before use, as they deteriorate with age when mixed.

To sensitize the paper, a small quantity of the mixed solutions is poured on the centre of a sheet, and then, by means of a camel-hair brush or tuft of cotton, it is spread evenly over the entire surface, and any surplus carefully removed. The paper is then hung up to dry, after which it is ready for use. All this must be done in a room lighted with gas, lamp, or weak yellow daylight, and the prepared paper must be kept in a cool, dry, dark drawer or closet, or it will lose its sensitiveness. In any case it

does not keep well for any great length of time, and for this reason it is not desirable to prepare more than is needed for immediate use.

The paper used should possess a hard close-grained surface, and should be well sized. Otherwise it will be necessary to mix about $\frac{1}{2}$ ounce of gum arabic with each of the stock solutions, to prevent the sensitizing liquid from sinking into the pores of the paper and thereby becoming difficult to wash out after the print is made.

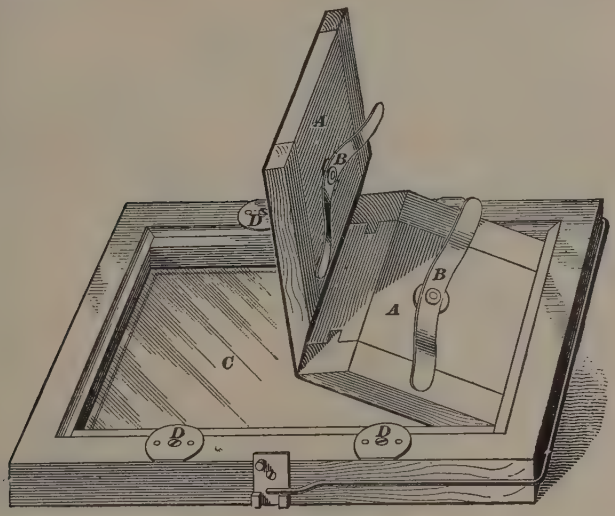

FIG. 69

234. Figs. 69 and 70 are two views of a printing frame that is well adapted to printing blueprints not over 21″ × 17″. The frame is placed face downwards, and the back *A* is removed by unhooking the brass spring clips *B*, *B* and lifting it out. The tracing is laid on the glass *C*, with the *inked* side downwards, touching the glass. A sheet of the prepared paper, perfectly dry, is laid on the tracing with the yellow (sensitized) side against the tracing. The paper and tracing are smoothed out so as to lie perfectly flat on the glass, the cover *A* is placed back into its

former position, and the brass spring clips B, B are pressed under the plates D, so that the back cannot fall out. All this is done in a subdued light. The frame is now placed where the sun can shine on it, and adjusted as shown in Fig. 70, so that the sun's rays will fall on it as nearly at right angles as possible. According to the condition of the weather, whether clear or cloudy, and the time of the year, the print should be exposed from 5 to 20 minutes. The progress of printing may readily be judged by turning the frame away from the light, carefully opening one-

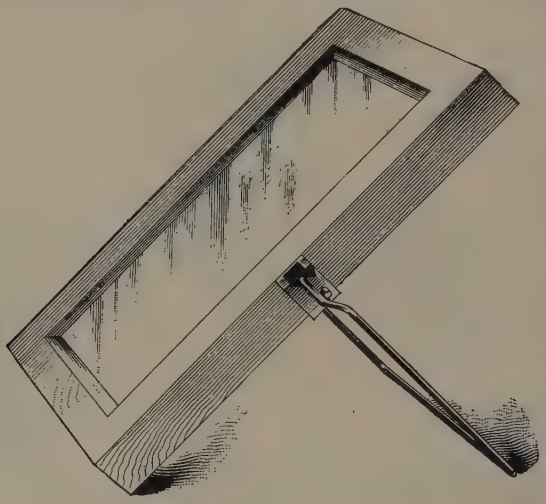

Fig. 70

half of the back and examining the exposed surface of the paper. If the time of exposure has been sufficient, the sensitized paper will have a blue-grey appearance, the lines remaining a greenish yellow. The opening of the back should be carefully done, so as not to displace the paper relative to the tracing.

235. A tray or sink somewhat larger than the print should be provided and filled to a depth of about 2″ with water. The print having been exposed the proper length of time, the frame is carried into a subdued light, where the cover is removed, and

the print taken out and placed in the water, with the yellow side down, and there left to soak while the next print is adjusted in the frame. The first print having been washed about 10 minutes, it should be lifted out by two of its opposite corners and rinsed thoroughly; then it should be hung up until dry. Should any dark-purple or bronze-coloured spots appear on the print, after it is dry, they indicate that there was not sufficient washing. If these spots are thoroughly washed before the print is dried, they will disappear.

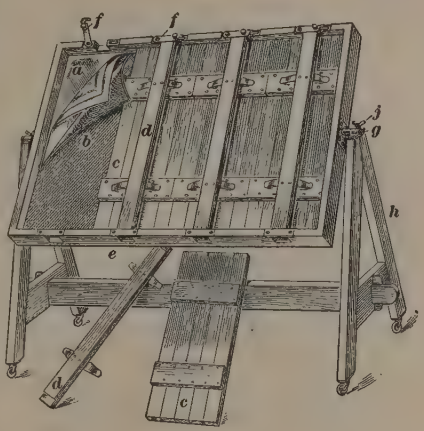

Fig. 71

236. For large tracings a printing frame, as shown in Fig. 71, may be used. It consists of a plate-glass front *a*, a felt pad *b*, backboards *c*, and pressure bars *d* with springs. These bars fit into sockets *e* at one end and are secured by metal clips *f* at the opposite end. If of large dimensions, such a frame is usually supported by trunnions *g* in a stand *h*, provided with castors so that it can readily be moved about. Thus supported, the frame can be turned horizontal for charging and tilted at an angle for printing. It is secured in position by the screws and nuts *j* on the ends of the trunnions. The backboards should be sawcut and battened, to prevent warping. The springs should be flexible and have about $\frac{1}{2}''$ movement in closing; if they are too stiff, there is risk of breaking the glass front. It is therefore better to use a large number of flexible springs. Some frames are made with the bars hinged at one end and the backboards also hinged together. It is far better to have all the bars movable and the backboards in interchangeable sections, so that they can be rapidly removed and replaced.

Various arrangements are used in offices for exposing frames to full daylight. In most cases a platform on which there are two rails is carried out beyond the window, and the frame may be provided with small wheels at the sides so as to be run out on the rails.

BLACK-LINE PRINTING

237. Ferro-Gallic Paper.—While blueprinting is the simplest, cheapest, and most generally used process, it has the disadvantage that it produces prints with white lines on a blue ground. This is particularly objectionable when it is desired to colour the prints, which is often the case in an architect's office. It is then preferable to have black-line prints that can be treated as ordinary drawings. Such prints may be made on *ferro-gallic paper*. **Ferro-gallic paper** is made in two kinds, the one being prepared in a water bath only, the other for development by means of gallic acid. There is no essential difference in the sensitizing chemicals ; the water-bath paper merely has the gallic-acid developer either incorporated with or rubbed over the sensitized surface. Water-bath paper is more convenient where only a small number of prints are required, and is largely used for home consumption. Owing to the presence of the developer, however, it is more likely to decay, and it is not as suitable for export to hot climates as the acid-bath paper, because the smallest degree of humidity causes the developer to become active, thus spoiling the sensitized coating and rendering the paper brittle.

Ferro-gallic paper of either kind is placed in the frame for exposure in exactly the same manner as ferro-prussiate paper. The exposure, however, will be 2 or 3 times as long, and should be carried on until the lines show a pale yellow on a white ground.

238. Water-Bath Paper.—To develop the print on water-bath paper, it should be placed face downwards in still water, all air bubbles being expelled. After about a minute, reverse the print and keep it moving in the water, or allow the water to run away and thoroughly flush the surface of the print with clean water for about 5 minutes. The action of the light on this paper is

exactly the reverse of that on ferro-prussiate paper, the ground being soluble, while the lines remain fixed.

Prints by this process should be very thoroughly washed, or the developing acid will remain in the paper and in time render it brittle, and the lines will also have a tendency to run.

239. Acid-Bath Paper. — To develop the acid-bath paper, place the print face upwards in the empty bath and pour on the surface a little developing solution. Distribute it thoroughly with a broad camel-hair brush until the lines become black, when the print must be well flushed with plenty of clean water. The developing solution is prepared by dissolving $1\frac{1}{2}$ to 2 ounces of gallic acid in boiling water, and afterwards adding sufficient cold water to make up a gallon. This may be kept for an indefinite time in an enamelled-iron bucket, stoneware jar, or bottle. It acts more rapidly on the print when at a temperature of 70° or 80° F. Stale water-bath paper gives better results if developed with the above gallic-acid solution. Good prints should show an indigo black on a white ground; such can be obtained only from perfect tracings, the lines on which are sufficiently dense to admit of ample exposure.

Over-exposure will produce mauve and broken lines on a white ground. Under-exposure, stale paper, opaque and dirty tracings produce a mauve ground. If the edge of the paper, exposed beyond the tracing and which naturally has been more strongly acted on by the light than the covered portion, turns white, while the portion covered by the tracing remains mauve, it indicates that the paper is good, but the exposure insufficient.

The cost of ferro-gallic paper is from 3 to 4 times that of ferro-prussiate paper. The prints by this process are not quite permanent, but will last for 1 or 2 years before fading. It is possible to obtain sensitized cloth, but this is rarely reliable and does not keep well.

FREEHAND AND ORNAMENTAL DRAWING

GENERAL PRINCIPLES AND EXERCISES

MATERIALS AND METHODS

INTRODUCTION

1. History of Ornament.—The history of ornament in architecture antedates all written history, for one of the strongest characteristics of the most savage tribes is their attempt at ornamental design, expressed in rude carving, or in the painting of their bodies, weapons, or utensils. In the earliest times, and even to-day with the savage, some element of the terrible or the supernatural generally enters into the design, but as man becomes civilized, his tendency in ornamental design leans toward the reproduction of natural forms, and self-glorification gives way to the desire to glorify and reproduce the forms found in nature round him, either in the animal or vegetable kingdom.

2. Although ornamentation really preceded architecture historically, it was the art of building that afforded the largest field for its development and application, for the finest achievements in the technical arts have been produced in the service of architecture ; and in all art industries, even wherein ornamentation seems to follow an independent existence of its own, its products are in harmony with the contemporary taste and tendency of architecture.

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3. Drawing of Ornaments.—A drawing is the representation of an object or combination of objects by means of a combination of lines, arranged so as to give the principal outlines and sometimes also the more important masses of light and shade. Drawing is not *designing*, but is the means by which ideas in design are expressed for general observation. To teach ornamental drawing in a comprehensive way would necessitate the teaching of the design and application of ornament; but this subject is not suitable for elementary instruction, and is only adapted to those who have already learnt to draw well, and are familiar with design in general. The aim of this Section is therefore to teach freehand drawing and the drawing of ornaments already designed. After having mastered the exercises given hereafter, the hand will have received an amount of training and the judgment of the eye will have been so far developed that the correct drawing of any object will be comparatively easy.

4. Ornament is either the embellishment of a structural feature accentuating its form and purpose, in which case it is usually carved or moulded in relief, or it comprises a flat-surface decoration, such as a carpet pattern, wallpaper, or a painted design. An ornament consists of a combination of straight and curved lines, independent, or joined with vegetable or animal forms, or exclusively of the latter, with or without colour decoration. Some ornament is purely geometrical in character, and can be drawn entirely with instruments; other is partly freehand and partly geometrical work; and the remainder is entirely freehand work. Ornamental drawing includes the rendering of form itself, being the representation of such graceful lines as exist in the animal and vegetable world, and also those of man's own invention, as seen in architectural mouldings, in the sweeps and curves of furniture, in the scrolls and twists of wrought-iron work, and in the outlines of pottery, glassware, etc. For instance, in an ornamental vase or a wrought-iron grille, the general form and the graceful lines and proportion of its parts are as much subject for ornamental drawing as is any individual ornament with which a part of either of those objects may be decorated.

5. How to Draw.—The making of a drawing can be said to consist of two parts, namely, the making of the individual lines and the composition. Straight and curved lines must be drawn in strokes, and not in dots or in a succession of short scratches. The strokes must not be jerky nor detached, but continuous, each being a continuation of the preceding one, and as long as one unconstrained movement of the finger joints will make them, which is about $\frac{3}{4}''$. No other method maintains so well the direction of the lines, nor develops so readily the pliability of the hand and the judgment of the eye as the making of a continuous line, instead of the making of a line piece by piece.

In ordinary drawing, the elbow may be rested on any part of the drawing-board that the case may require; but the ball of the hand should be as free as possible, in which position the hand will rest and travel along lightly on the first joint of the little finger.

6. The *eye* must guide the hand in drawing, but should not be riveted too closely on the pencil or drawing pen; a glance forwards and backwards over the work, to compare the *form* of the design and the direction of the lines, will enable the work to be kept close to the copy, which is all that is at present desired.

The draughtsman, sitting at work, should avoid bending over the drawing in a cramped position, as it is likely to injure his eyesight, and will in no way benefit his work. An easy natural attitude is the best. All subjects should be outlined in their normal aspect, not upside down or sidewise, the paper being straight in front of the draughtsman; but, in the final rendering, especially in the inking, there is no objection to turning the sheet or to turning the body into such a position as to make the work more convenient and thus produce more perfect lines.

7. Materials Used.—The pencil recommended for use is one corresponding to Hardtmuth's Koh-i-noor or Wolff & Sons' selected leads. The most suitable grade will depend on the individual taste, but probably a HB is most suitable for general freehand drawing. For aiding in the work, a *soft rubber* may be used to advantage, to clean up the drawing after the sketch is complete, and just previous to the process of inking in. The

final pencil lines must be firm and clean, but not heavy, and, if any corrections are necessary, an ordinary *white rubber* should be used. A uniform round pencil point should be maintained, of medium length, and continued sharpening should be avoided, as a good point can be kept by turning the pencil as the work proceeds. Avoid cheap pencils; they are a delusion as to economy, and their inferior lead smears the drawing. Three golden rules to be observed are: *Never wet the pencil; never use a hard pencil; never use a short pencil unless it is inserted in a holder.* The pencil should be not less than 5″ long, in order that it may rest against the knuckle of the forefinger.

8. Almost any smooth paper may be used, so long as it has a hard surface. Before commencing a drawing the paper should be tested by drawing a pen across its surface to see that it moves freely and smoothly and leaves a fine unblurred line of ink. Bristol-board has an excellent surface for drawing on, especially in ink, but is more expensive than most of the drawing papers. Pens of various brands are made specially for drawing, and although certain of these are excellent in the hands of an experienced draughtsman, they would not be suitable for the beginner. Gillott's No. 303 will make as fine a line as is necessary or desirable in a pen drawing that is intended for practical work; Gillott's No. 404 is suitable for bolder lines, while C. Brandauer's Oriental pen is suitable for medium work. An ordinary old-fashioned quill pen is very serviceable for work where a broad rich line having something of the quality of a brush line is desired.

9. The beginner should not use too fine a pen; probably the Oriental would suit him well, but as he perfects himself in free-hand drawing he may use a pen capable of a wider range in thickness of lines. Pens should not be constantly changed; one kind should be used until one has become familiar with it, as a great deal of practice is necessary to train the hand and pen to work together in harmony. The pen should be drawn *toward* the draughtsman when possible, but when it is moved sidewise the pen should be turned so that the under side moves away from the line being drawn, or, in other words, so that the under side faces in the same direction in which the pen moves.

The rules given for the use of the pencil do not apply entirely for using the pen. It should, for instance, be possible to make a drawing in pencil while the paper remains stationary, that is, without turning it in one direction or other for the purpose of drawing the lines more easily according as they change in direction. With the pen this cannot be so, by reason of the fact that it can draw a perfect line only in *one* direction. If, therefore, the rule is to be adhered to, that the pen is always to be drawn *toward* the draughtsman, it follows that, while a curved line is being drawn, it will be necessary repeatedly to change the position of the paper. Otherwise the pen will at times have to move upwards or sidewise.

10. Perfectly black Indian ink of any kind may be used for finishing the drawing plates. Black ink is absolutely necessary if the drawing is for reproduction by photo-engraving, and in any case the effect of the drawing is materially damaged by any variation in the colour of the ink with which it is drawn. Several inks on the market give satisfactory results. Among these are Higgins's drawing ink, Winsor & Newton's Indian ink, and l'Encre de Chine Liquide, a French product that is of practically the same value. If preferred, ink may be made as required by procuring a stick or cake of Indian ink and rubbing it down in a saucer of water, but this is not so convenient as the ready-made liquid inks mentioned.

11. **General Outlines.**—Before beginning to draw a figure, its general effect and characteristic shape as a whole should be carefully observed. The individual form, the curves and scrolls, and the character of the foliage should then be studied. Its symmetry, the proportion of its parts, and the general direction of its principal lines should all be borne in mind during the entire process of sketching it in. As to the size of the drawing in

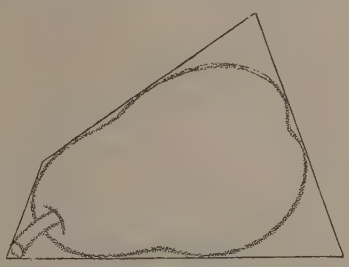


FIG. 1

relation to the copy, model, or natural object, it is sufficient to state that some definite scale of enlargement or reduction should be followed, so that everything can be maintained in equal relative proportion. In beginning to draw an object, first set out the extreme outline, as in Fig. 1 ; then fix the principal points of extent and position by estimating their distances from the base and centre lines. The extreme outline should be composed of a few straight lines so arranged as to enclose the object in an irregular geometrical figure. The curves and other details of the object may then be rounded in at the angles of the geometrical figure, as shown.

12. For the setting out, extreme exactitude is not required ; there should, in fact, be as little mechanical measuring as possible, all minor distances being judged by the eye. Use the eye as much as possible, in order that it may become trained to judge correctly absolute and relative sizes, and form and proportion. The value of this accomplishment to the draughtsman and designer cannot be overestimated. It holds within itself the entire principle of freehand drawing. Since the object is to learn to draw, and, in a measure, to obtain a knowledge of ornament, the points just given are of far greater importance than the mere act of repeating or copying of lines. The purpose of this Section is not that of making copyists.

13. While the use of drawing instruments and mechanical appliances is necessary in blocking out the preliminary work of any design, the design itself must, in nearly all cases, be executed freehand, or at least partly so. For this reason, the work in this Section will be entirely freehand. Practise constantly on other work than these plates, so that the hand may become subtle and the style systematic and individualized. In freehand drawing, the work may be executed by means of different materials, but only two of these will be considered here, as they are the ones most frequently used and the only ones necessary except in special cases. The most common drawing material is the lead-pencil, and the object is either drawn in outline, as indicated in Fig. 2 (*a*) and (*b*), or shaded, as in Fig. 2 (*c*). If an outline drawing, the object may be expressed

in lines conforming to the actual contour of the object itself, as in Fig. 2 (*a*), or it may be drawn as it appears to the eye, as in Fig. 2 (*b*). In the former case, the drawing is called an

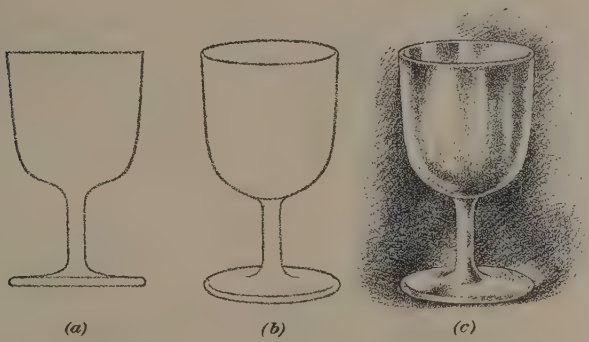


FIG. 2

elevation of the object; the latter is a **perspective view.** In a shaded drawing the form of the object is not alone brought out more clearly, but also its surface characteristics.

14. Drawings are also executed with pen and ink, the general appearance being the same as in pencil; the method of execution is different, however, as will be explained later. In fact, in the majority of cases a drawing is outlined in pencil, and then inked over and shaded with the pen.

Another method of drawing, and one used extensively by all designers, is that of drawing with the brush. Its use is limited to freehand work, but its application is extended to designs in colour and half-tone.

Mechanical drawings are executed to scale, or in exact proportion according to measured dimensions. Freehand drawings are executed almost entirely with the unaided hand, and measured by the judgment of the eye. The expert designer uses eye measurement almost exclusively, and particular attention should be paid to this feature of freehand drawing, as it will be indispensable hereafter.

PRELIMINARY EXERCISES

15. Training the Hand.—As the eye and hand must always work together, both should be put in training in order to co-operate successfully. The untrained eye is eager and alert, but it does not see intelligently. The hand that in other work may be deft and clever is usually clumsy when it first takes up drawing, and must also be trained to execute readily what the eye will soon be quick to discern. It is therefore necessary that some simple exercise be practised in order to accustom the eye and hand to co-operate. It is very important that the closest attention be paid to the following simple exercises with the pencil in order that one may proceed intelligently with the

FIG. 3

more difficult and more interesting work that follows. It is not sufficient that the following exercises are correctly made. It is also necessary that they are practised repeatedly until an experience is attained sufficient to enable one to control the hand or arm in the motion of the pencil and cause it to travel just as the mind dictates.

In order to produce different effects it is sometimes necessary to hold the pencil in different positions, but for general sketching it should be held lightly, but firmly, between the thumb and first two fingers, about $1\frac{1}{2}''$ or $2''$ from the point, as shown in Fig. 3, much as in ordinary writing, with the hand resting lightly on the little finger.

16. These preliminary exercises should be executed on paper fastened to a drawing-board. It is not necessary to set apart on the paper a special space for each particular exercise, as the purpose of this work is simply that of training the hand to some extent before the work on the plates is begun.

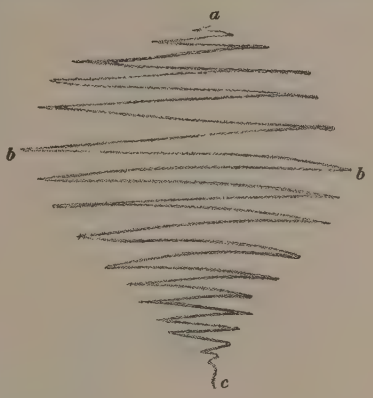


FIG. 4

The simple zigzag line shown in Fig. 4 should first be practised repeatedly until it is possible to increase and decrease the sweeping motions of the pencil with a degree of uniformity that will cause the outline, formed by the sharp turns of the zigzag line, to form an evenly graded curve from *a* to *b*, *b* to *c*. Exercises similar to those shown in Fig. 5 should not be considered satisfactory, as they are crude and uneven. Repeated practice will enable one to conform more to what is required and to train the hand so that its motions will go no farther than is necessary. Fig. 4 is formed by carrying the pencil with an even swinging motion from right to left and back, the hand swinging on the wrist as a hinge.

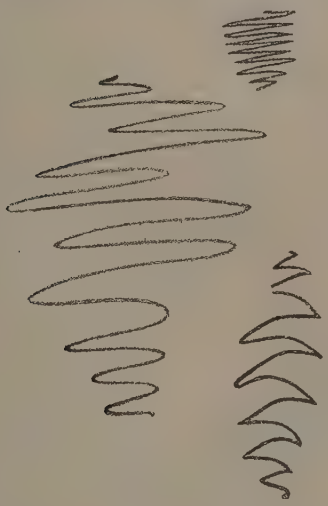


FIG. 5

After practising this exercise repeatedly the exercise shown in Fig. 6 may be begun, where, it will be observed, the motion is similar, but the general direction and the resulting form of

the surface covered is altered. As the pencil descends in these zigzag curves the pressure is, in the first example, gradually decreasing. In the second example the pressure increases at the angles, as shown at *a*.

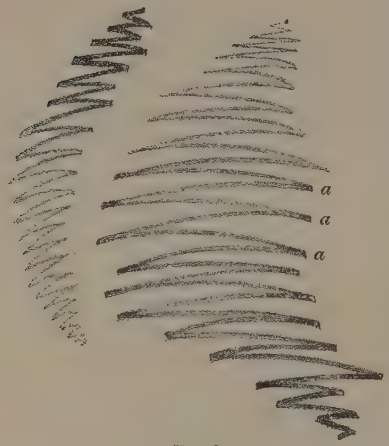


Fig. 6

Simple as these two exercises may appear, too much attention cannot be given to them by the beginner, as on their free and successful execution depends much of the broadness that should be displayed in future work.

17. In Fig. 7, the direction of the stroke is different from that in the previous figures; the hand is turned to rest on its outer edge, while the elbow must be moved farther from the body. The fingers grasp the pencil nearly in the same manner as before, but it is held obliquely toward the left. With the hand in this position a number of such exercises as *a*, Fig. 7, should be practised, after which the effect may be increased by combining a series of these exercises in order to cover the surface more thoroughly, as shown at *b*. At *c* is shown a method of covering the surface with an even

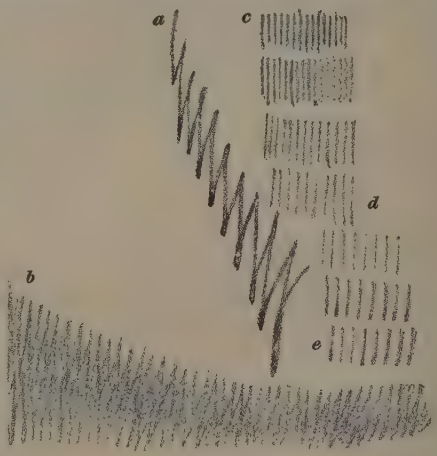


Fig. 7

tint, which may be graded in depth by varying the amount of space between the lines and by changing the strength of the lines themselves, as shown at *d* and *e*. This gradation of shade

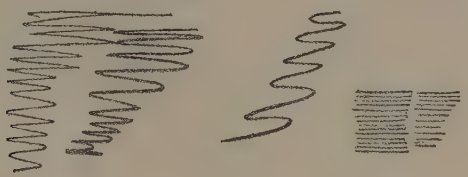


Fig. 8

does not form a part of the present exercises, but will be required in some of the plates that follow in other Sections. Exercises of this kind will nevertheless, besides giving practice in surface shading, also be a means for acquiring skill in using the pencil for drawing outlines. It is important that all attempts at surface shading be kept within the bounds of an even tint, as it is a simple matter to grade a tint when sufficient experience has been gained to produce one tint smoothly and evenly. These exercises should now be repeated, but with the strokes in a horizontal position, as shown in Fig. 8; to do this it will be necessary to change the position of the pencil and to draw the elbow nearer the body, in order that the horizontal lines may be more readily executed.

Fig. 9

18. In Fig. 9, the exercise becomes more complicated and leads into the first stages of the style of rendering used for foliage. Close attention should be given to this, as the rendering of foliage is one of the most intricate problems in drawing, but it is at the same time the most interesting, and therefore the method of its handling is of importance.

To practise Fig. 9, the pencil should be held in a similar manner to that used for Fig. 7, but can be varied somewhat in order to render the various inclinations of the lines more readily.

The series of oblique lines at *a* are drawn from left to right slowly and evenly, the hand gradually descending as each stroke is completed, while the lines shown at *b* are drawn from right to left in the same manner until they intersect with the first lines as shown. At *c*, a series of short curved lines is drawn in the same way, and should be practised from both right to left and from left to right, as circumstances are likely to arise where both methods of execution will be desirable. Having continued this practice until sufficient skill has been acquired, the surface shading, shown at *d*, should be practised, where a combination of the rendering shown at *a* in Fig. 7 and that of *a*, *b*, and *c*, Fig. 9, is effected.

Constant practice on these simple exercises cannot be urged too strongly, as familiarity with their power of expression must be learnt before it is possible to attempt other and more important work.

DRAWING PLATES

GENERAL INSTRUCTIONS

19. The exercises contained in this Section are given on five drawing plates, each one of which is to be drawn on a sheet of paper of the size used in *Geometrical Drawing*, that is, $18'' \times 14''$. A border line is drawn $\frac{1}{2}''$ from each edge, thus leaving a clear space $17'' \times 13''$ on which the drawing may be made. The sheet itself should be larger than is required for the finished drawing, so that the outer edges containing the drawing-pin holes may be cut off. This extra margin will be found very useful for testing the pen, in order to see whether the ink is flowing freely and that the pen point is clean.

All drawings should be made as neat as possible, and the pencilling for each figure entirely finished before inking in any part of it. This means that the pencil drawing shall not alone contain all the lines required, but also that the strength and gradation of these lines shall be according to the requirements of the finished drawing, as shown on the plate. It must not be

supposed that the pencil drawing merely serves as a basis for the pen drawing. On the contrary, in these examples the pen drawing simply serves the purpose of reproducing the pencil drawing in ink, so as to make it more permanent. The figures on the plates should be drawn several times on a separate sheet of paper before commencing the finished drawing plate, as by this means the hand and eye will be trained and better results obtained on the final drawing. The pencil work should be executed with the board squarely in front, in order that the form and proportions of each figure may be studied in their proper position.

20. Great care must be taken in distributing the different views, parts, details, etc., on the drawing plate, so that when the plate is completed one view will not be so near to another as to mar the appearance of the finished drawing. The hands must be kept perfectly clean, and should not touch the paper more than is absolutely necessary. It is a good plan to keep a sheet of blotting or other paper over part of the drawing plate on which the hand can rest, so as to prevent moisture from the hand getting on to the drawing. No lines should be erased except when *absolutely* necessary ; for, wherever a line has once been erased, and the finished surface of the paper thereby removed, it becomes difficult to draw on this part of the paper and it soils very easily. For this reason, all construction lines that are to be removed, or that are likely to be changed, should be drawn lightly, so that the finish of the surface may not be destroyed when erasing them. If it is found necessary to erase an ink blot, or a line that has been inked in, only an *ink eraser* or *sand rubber* should be used, but not a knife. After the erasure has been made, the roughened part of the surface of the paper can be smoothed by rubbing with some hard smooth substance, as a piece of ivory or the handle of a knife. In this way the loosened fibres of the paper are pressed down and the surface improved, so that an inked line may be drawn successfully.

In order to distinguish readily between references to figure numbers on the drawing plates and those in the text, the figure

numbers on the former are printed in heavier type throughout this Section. For instance, Fig. 1 refers to an illustration in the text, while Fig. **1** refers to a figure on the plate.

DRAWING PLATE, TITLE: LINES

21. The exercises on this plate are to be drawn for the purpose of training the eye and hand to work together, and thereby to become sufficiently practised to execute the designs that follow. The drawing of a single line is of as much importance as the execution of an entire design, and much time must be given to constant and patient practice until each simple problem is mastered before the next is attempted.

Before beginning the drawing plate it is best to practise the exercise, shown in Fig. **1**, on a separate sheet of paper fastened to the drawing-board. The latter should be squarely in front, and the elbow should rest near the bottom of the board, somewhat to the right of the drawing. A short straight line is then drawn, as from *a* to *b* in Fig. 10 (*a*), and the arm is then shifted a little lower down on the board, and another line, as *b c*, is drawn, care being taken that there is a space of at least $\frac{1}{32}''$ between the end of the line *a b* and the beginning of the line *b c*. A third section of the line is then drawn from *c* downwards, and so on, until the line is of the desired length. If any difficulty is found in drawing these lines vertical, straight, and parallel to each other, it is advisable that at first a series of light pencil lines be drawn by means of the **T** square and a set-square. These lines will then serve as guide lines until greater proficiency is obtained. Such guide lines should not be used in drawing the exercises on the plates.

22. Having practised the exercise several times, the spaces between the sections of the line should be gradually decreased until it appears as a straight unbroken line, as shown at *d e*. It is necessary to be still more careful in doing this, lest the lines overlap one another or curl out at the ends. The former error causes the finished line to appear somewhat as at (*b*) in Fig. 10, while the line composed of strokes whose extremities

LI

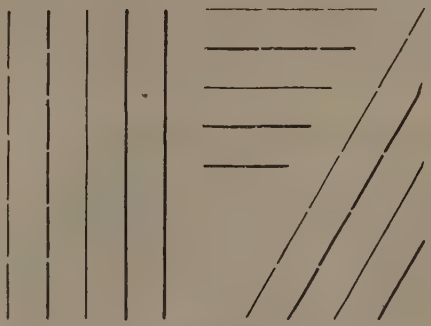


Fig. 1

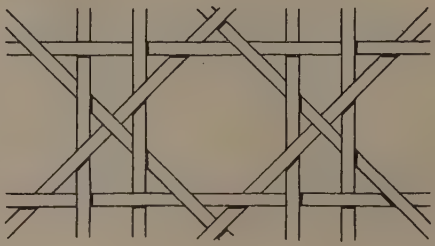


Fig. 4

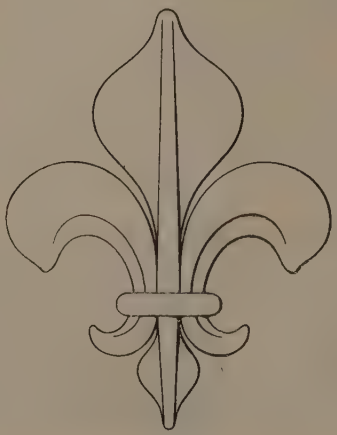
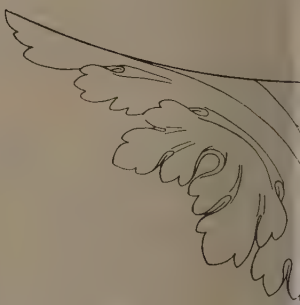


Fig. 7.



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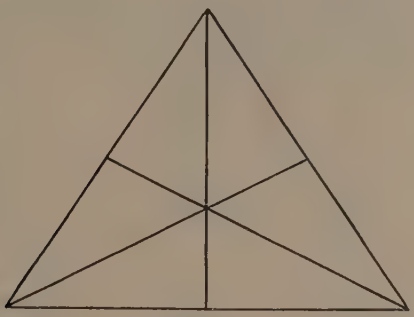


Fig. 3.

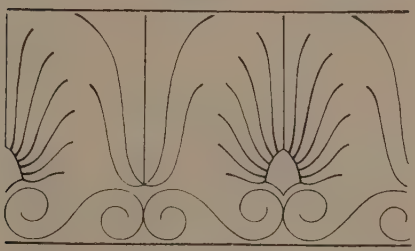
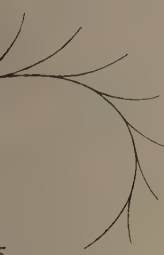


Fig. 6



5.

Fig. 9.

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are curled would appear ragged, as at (*c*). The strokes with which these lines are made are not short, quick dashes of the pencil or pen, but slow, even marks, each of which is started carefully, drawn slowly, and finished abruptly, so as to show a clean, even stroke, the same thickness and depth of colour throughout, and clean cut, that is, without ragged edges, from end to end. The second stroke must never lap over the first, and it is better to let a hair-breadth space remain between the ends of the lines than to have the least suggestion of a line like that at (*b*). When sufficient proficiency has been acquired in this exercise, the drawing plate may be begun.

FIG. 10

23. It is desirable that the figures on the plate be symmetrically arranged and sufficient space left for all of them; it is therefore advisable that they should be arranged according to the instructions given hereafter. The lines shown in Fig. **1** are supposed to be contained in a rectangle 4″ long and 3″ high, which may be outlined in pencil on the plate by means of a **T** square and set-square. Place its upper side $1\frac{1}{2}$″ below the upper border line and leave a space of 1″ between the left-hand border line and the adjacent side of the rectangle. A space $\frac{3}{8}$″ wide should be left between the several lines and also between each group of lines. Set off point *a*, Fig. 11, at a distance of $1\frac{7}{8}$″ from *d*, and point *b* a distance of $1\frac{1}{16}$″ to the right of *a*. Draw with a pencil the vertical *a c* and connect points *b* and *c*. The triangle *a b c* will enclose the horizontal lines of Fig. **1**. Draw *e f* parallel to *b c*, thus giving the correct inclination to the slanting lines in the exercise. It will be seen that two of the vertical

lines consist of separate parts about $\frac{1}{2}''$ long. The remaining three lines have to be drawn in such a manner that the spaces between the separate parts are not noticeable.

24. Commencing with the line *a b*, Fig. 11, the drawing of the horizontal lines, shown in Fig. **1**, should now be practised in a similar manner, except that in this case the *right* elbow should be moved nearer the body. While drawing the strokes forming the horizontal lines, the whole arm should be moved toward the right to prevent the lines from assuming a curved form, as would be the case if the elbow remained fixed and the hand were moved only so far as the swing of the arm would permit. The method of forming one straight line by the careful union of several smaller ones remains precisely the same for horizontal as for vertical lines.

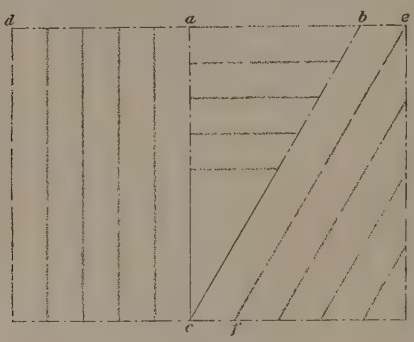

FIG. 11

25. The final exercise to complete Fig. **1** is the drawing of the oblique lines shown, which will be found easier to draw, as the slope of the lines corresponds somewhat to the inclination of letters in ordinary handwriting ; consequently the hand will work in its customary position. After practising these lines three or four times on a separate sheet of paper, those on the plate may be proceeded with. These lines are limited in length by the remaining part of the rectangle, and they may be drawn in the same manner as the other two series of lines.

26. In Fig. **2** is shown a horizontal line crossed at its centre by a perpendicular line, thereby forming four angles of 90° each. The eye must learn to judge angles accurately, as well as the length of the lines on each side of the point of intersection, as many instances will occur later where accuracy of judgment in this particular is essential. This exercise should be drawn

repeatedly on a separate piece of paper before commencing the finished drawing, and the lines should be set out entirely freehand without the aid of a set-square, though after the lines have been drawn the accuracy of the work may be tested by means of a set-square to see that the angles are true. Set off a point *a*, Fig. 12, $6\frac{1}{2}''$ from the left-hand border line and 3″ below the upper border line, and begin the horizontal line at this point. At a point *b* $8\frac{1}{2}''$ from the left-hand border line and $1\frac{1}{2}''$ below the upper border line begin the vertical line and make the latter 3″ long.

Fig. 12

27. In Fig. **3** is shown a triangle with lines drawn from each angle to the centre of the opposite side. The base line *b c*, Fig. 13, is first drawn, the point *b* being 5″ from the right-hand border line. From the centre of this base line, which is 4″ long, a perpendicular *a f* is set up and made 3″ long. Then, points *a*, *b* and *a*, *c* are joined, and lines are drawn from the centre points *e*, *d* of *a b* and *a c* to *c* and *b*, respectively. Great care should be taken in drawing this exercise, as the completed figure indicates at once the degree of accuracy with which the drawing was made If the three lines drawn across the triangle from the points *a*, *b*, and *c* do not intersect in the point *g*, the drawing is faulty at some place.

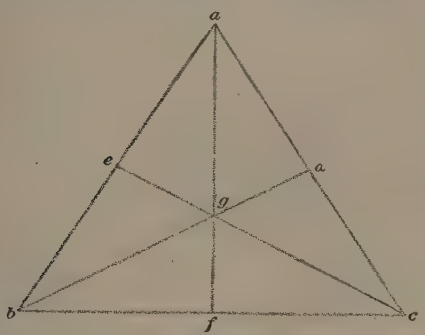

Fig. 13

28. In Fig. **4** is shown an example of Arabian interlacing ornament, the drawing of which combines many of the exercises already practised in Figs. **1, 2,** and **3.** It will be noticed that this ornament can be bounded by four straight lines forming a rectangle, as shown at *a b c d*, Fig. 14. On the drawing plate, the dash-and-dot lines shown in Fig. 14 should be drawn in pencil by means of a **T** square and set-square, but as they are construction lines they will be rubbed out when the drawing on the plate is inked in. Proceed to draw the rectangle *a b c d* on the drawing plate, fixing the point *a* $7\frac{3}{8}''$ below the upper border line and 1″ from the left-hand border line. The rectangle is to be $4\frac{1}{16}''$ long and $2\frac{1}{4}''$ high.

29. Having completed the rectangle, divide it into four equal rectangles by the lines *g h*, *e f*, which connect the centre points of opposite sides. Bisect *a e* and *e d* at *i* and *k*, and from these points draw lines *i j* and *k l* parallel to *e f*. The construction lines for this figure will now be complete and the lines forming the interlacing ornament may be drawn. It will be noticed that

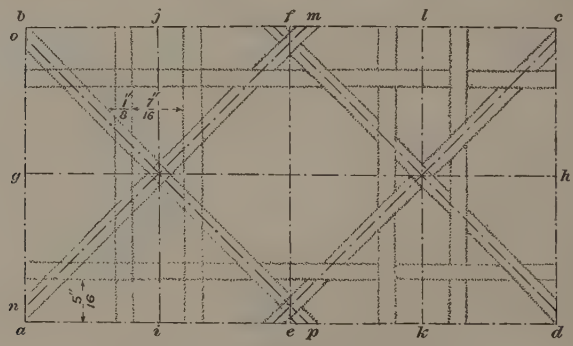

Fig. 14

the left-hand part, Fig. 14, is drawn with all the lines in full, irrespective of the fact that at some places they should be invisible. Only the right-hand half is drawn correctly showing the overlapping parts. The whole of the figure should first be set out in pencil in a manner similar to the left-hand portion of Fig. 14; the exercise, when inked in, will appear as Fig. **4.**

30. To set out the lines of the ornament commence with the vertical strips on each side of the construction lines *i j* and *k l*. The strips are all $\frac{1}{8}''$ wide, and the vertical ones are set out $\frac{7}{16}''$ apart and equidistant on each side of the lines *i j*, *k l*. The two horizontal strips are set out parallel to *b c* and *a d* and at a distance of $\frac{5}{16}''$ from each of them, respectively. To set out the diagonal strips, the points of intersection of the construction lines *g h* with *j i* and *k l* must be taken as centres of the strips, through which points centre lines, such as *m n* and *o p*, may be drawn by means of a 45° set-square. At a distance of $\frac{1}{16}''$ at either side of these centre lines the outlines of the strips are drawn by freehand.

When instructions are given in the following examples with reference to the construction of rectangles, triangles, circles, etc., which are to serve as a basis for the drawing, or as means by which it may be correctly placed on the plate, then such guide figures should be drawn by means of instruments. Otherwise, all lines should be drawn by freehand, except when special instructions are given to the contrary.

31. A few remarks are here necessary as to the use of instruments, such as squares and compasses, in making freehand drawings. When ornaments of the kind shown on the plates in this Section are drawn in practice, advantage is taken of means and methods that will facilitate the making of the drawings, both as regards the saving of time and labour. It is natural to suppose that an architect does not intentionally make his work more difficult than it need be. Consequently he will use guide lines, drawn by means of a **T** square and set-squares; he will also subdivide lines into a given number of parts by means of compasses. Ornaments that are circular in outline or contain circular elements are also drawn much more readily if a circle or circles, drawn by means of compasses, are used as guide lines within which the details of the ornaments may be arranged.

32. While such methods are permissible in the case of an experienced draughtsman, they are not to be recommended for the beginner except to a limited extent. A free use of

mechanical means by which to obtain more accurate and quick results would be detrimental to his acquiring the necessary training of hand and eye. If the beginner, whenever he is in doubt of the correct spacing or inclination of lines, will resort to the use of compasses, he will never learn freehand drawing. It is therefore strongly recommended that, whenever some parts of the exercises are found particularly difficult, the extra effort required in completing them should not be shirked by using instruments as an aid, but that, on the contrary, the particular part be repeatedly practised on a separate sheet of paper until the difficulty is surmounted. Otherwise, real progress is impossible.

33. In Fig. **5** is shown an example of radiating lines such as are often found in nature, particularly in the veins of leaves. It exemplifies the three fundamental principles of foliated ornament, where:

1. All lines should radiate from a parent stem.

2. All branching lines should be tangent to the line from which they branch.

3. There should be a proportionate distribution of areas between the parent stem and the branches.

In Fig. 15 it will be seen that *a b* is the parent stem, and the curved lines *a c*, *a d*, etc., all radiate from it and are tangent to it. As seen from Fig. **5**, the parent stem has the greatest breadth or thickness and each of the branches has a thickness proportionate to its length and to the position it occupies on the parent stem, that is, to its distance from the thick part of the stem. These principles should be clearly understood, as they form the basis of all foliated ornament; they will be further exemplified as the work proceeds.

34. It will be seen from Fig. 15 that this example can be set out on the basis of a square *a e f g* with sides $3\frac{3}{8}''$ long. This square should be placed on the drawing plate with its side *a g* at a distance of $6\frac{3}{4}''$ from the left-hand border line and its side *a e* at a distance of $8\frac{1}{4}''$ from the top border line. Draw in the diagonals *a f* and *g e*, also the lines *j k* and *h i* parallel to the sides of the square and passing through the

point of intersection *l*. The main construction lines for Fig. 5 will now be complete, and the drawing of the figure may begin. Commence at *a* the parent stem *a b*, and mark on the

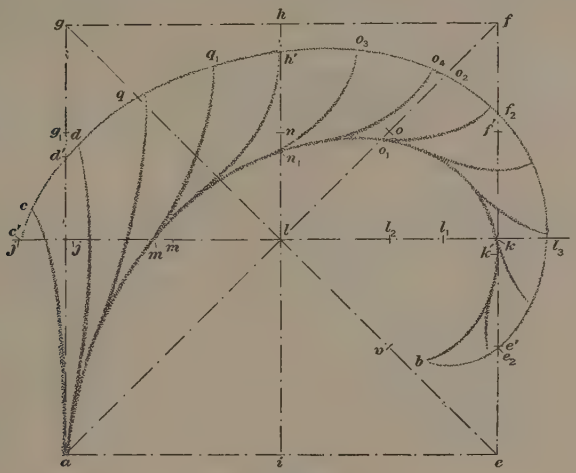

Fig. 15

various construction lines where it should cut them, gauging the distances of these points from the guide lines and their points of intersection *only* by means of the eye in the manner now to be explained.

35. The ability of gauging distances by means of the eye alone is really one of the most important requirements in freehand drawing. To some persons this acquisition comes more easily than to others, but in either case it must be cultivated and practised until the function becomes entirely instinctive and automatic. The greater the distance between two given points in a drawing, the greater will be the difficulty of estimating the distance by the eye, so as to be able to mark on a separate sheet of paper two points similarly spaced. But if the distance between the points on the drawing is halved, the problem is at once made much easier.

36. This faculty of dividing lines accurately into halves is a great help in freehand drawing and one that is worth cultivating. It will therefore be time well spent if the beginner will draw a series of vertical, horizontal, and inclined lines of variable lengths, and then, beginning with the shorter lines, seek to divide these lines into exact halves. The accuracy of the divisions should subsequently be tested by means of dividers. It is surprising how easy it will be found, even after a short practice, to divide a line into exact halves. Later on the division of lines into three and four parts may be practised.

37. How the subdividing of a line into halves may be used as an aid in freehand drawing will now be shown by means of Fig. 15. The line $j\,l$ is first divided into halves by marking the point m. As there now is only a short distance $m\,m_1$ between m and point m_1, where the stem crosses $j\,l$, it is easy to mark the correct position of point m_1. Similarly, on dividing $h\,l$ into halves at n, the point n_1 may readily be marked in. Again, if the centre of $f\,l$ is marked at o, the crossing point o_1 is found at once. It is further noticed that the stem is tangent to $e\,f$ at k', a short distance below k. Finally, marking the centre p of the line $e\,l$, there should be no difficulty in finding the correct position of b relative to p.

38. As a guide in drawing the radiating lines in Fig. **5** there has been added the curved outside line $c\,d\,l_3\,b$, which limits their lengths. When, in the succeeding instructions for drawing these lines, minute details are gone into as to the means by which to find the position and length of each line, it is to be understood that the various subdivisions of the guide lines required would not, by an experienced draughtsman, actually be made with the pencil, but would be carried out mentally. The detailed description given here is simply to serve as an example how the method of subdivision may be applied. In other examples it will be taken for granted that full advantage is taken of guide lines as a means for fixing the positions of the principal points in a drawing.

39. Before beginning to draw the curve $c\,d\,l_3\,b$, it is best to produce line $j\,k$ in both directions and to mark off $j\,j'$ equal

to half of $j\,m$; the position of c' is then easily found; equally easy is the fixing of d_1 below the centre point g_1 of $g\,j$. If $g\,l$ is divided into thirds, the distance $g\,q$ will be exactly one-third of $g\,l$; similarly will $h\,h'$ be a quarter of $h\,n$. Proceeding to point o_2, it will be seen that $o_2\,f$ is exactly half of $o\,f$, and also that f_2 is only a short distance above the centre point f' of $f\,k$. If the line $k\,l$ is imagined as being divided into fourths, such as $k\,l_1$, $l_1\,l_2$, it is noticed that point l_3 is a little less than a distance $k\,l_1$ to the right of k. Finally, point e_2 coincides nearly with the centre point e' of $e\,k$.

40. The insertion of the radiating lines will now be relatively easy, the details requiring special care being the correct marking of the points where the lines leave the parent stem and also providing them with the correct curvatures at these places. The finding of the points where these lines touch the curved line $c\,d\,l_3\,b$ should, if the method of subdividing lines is fully understood, need no additional instructions. For instance, points q_1 and o_3 are half-way between $q\,h'$ and $h'\,o_4$, respectively. The other points are so near some of the main points that their positions can be fixed at once. Great care should be taken to give the stem and each of the radiating lines the correct thickness throughout their entire length.

41. In Fig. **6** is shown an example of anthemion ornament taken from a Greek vase. The anthemion was a conventionalized honeysuckle ornament, and existed in many varieties in Greek and Roman architecture. The term *conventional*, or *conventionalized*, is used to designate a floral or other design in which the original form has been simplified and changed so that it may be drawn by a system of geometrical construction lines. For instance, Fig. **7** is a representation of a flower of the lily class, but is drawn so that each half, as divided by the vertical centre line, is a duplicate of the other half, a condition which would never exist in nature, but which is desirable in certain classes of ornament.

42. It will be seen from Fig. 16 that the extreme points of this ornament can be enclosed in a rectangle $a\,b\,c\,d$. Set out this rectangle on the drawing plate, making the side $c\,d$ 4″ long,

and placing the point c 1″ from the right-hand border and $5\frac{1}{2}$″ above the lower border line. Next draw in the vertical centre lines $e\,f$ and $g\,h$, placing $e\,f$ $1\frac{3}{8}$″ to the right of and parallel to $a\,d$, and $g\,h$ $1\frac{3}{8}$″ to the right of and parallel to $e\,f$. Another construction line $i\,j$ will be required for determining the height of

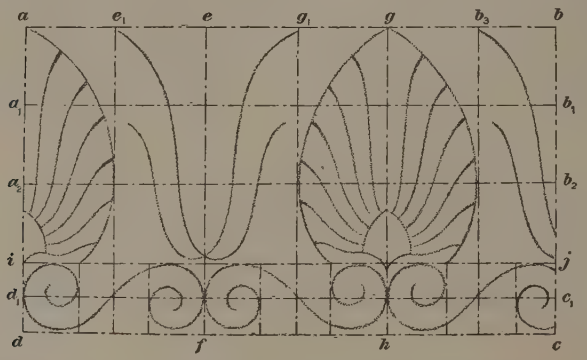

Fig. 16

the small scrolls; this should be drawn parallel with $d\,c$ and $\frac{9}{16}$″ above it. The vertical construction lines enclosing these scrolls can be drawn between $i\,j$ and $d\,c$ on each side of the centre lines $e\,f$ and $g\,h$, and to the left and right of $b\,c$ and $a\,d$, respectively, in each case at a distance of $\frac{7}{16}$″, except in the case of line $b\,c$, where the distance is $\frac{5}{16}$″ only.

43. Additional guide lines are obtained by dividing some of the sides in the following manner: First the line $a\,i$ is divided into three equal parts, and lines $a_1\,b_1$ and $a_2\,b_2$ drawn parallel to $a\,b$. Next $a\,e$ and $e\,g$ are each divided into two equal parts, giving points e_1 and g_1; then $g\,b_3$ is set off equal to $g\,g_1$ and verticals drawn through these points. Finally, point d_1 is placed at the centre of $i\,d$ and the line $d_1\,c_1$ drawn parallel to $c\,d$.

The curves enclosing the radiating lines at $a\,d$ and $g\,h$ must be drawn carefully, commencing at point g and letting the curve assume the farthest distance from the centre line $g\,h$ where the curve crosses line $a_2\,b_2$. If the principal lines in this figure are inserted in a systematic manner, according to the method

explained with reference to Fig. 5, there should not be any serious difficulties to overcome.

44. In Fig. 7 is shown an example of a conventionalized lily, almost universally known as the *fleur-de-lis*, which is a French term meaning *flower of the lily*. This figure can be set up on the lines shown in Fig. 17. The whole figure is first enclosed in the equilateral polygon *a b c d* and the diagonals and subsidiary construction lines are set out afterwards. On the drawing

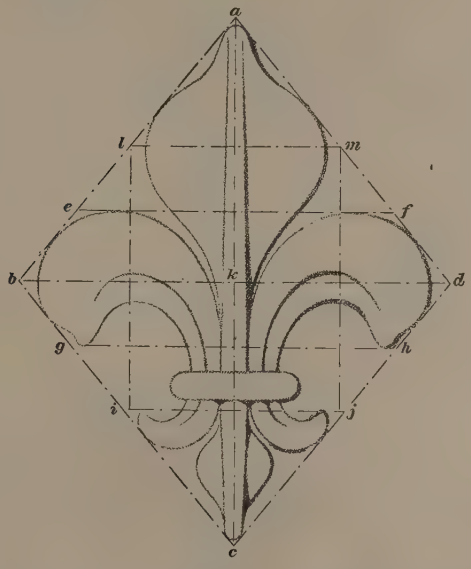

FIG. 17

plate commence by setting off the point *c* at distances of 1″ above the lower border line and $2\frac{1}{2}$″ from the left-hand border line. Erect a vertical at *c* $4\frac{1}{8}$″ long. Through the centre *k* of *a c* draw *b d* at right angles to *a c* and $3\frac{3}{8}$″ long. Now set out the horizontal lines *e f* and *g h* $\frac{9}{16}$″ above and $\frac{1}{2}$″ below *b d*, respectively; likewise draw the horizontal *i j* $\frac{1}{2}$″ below *g h*. These lines will fix the boundaries of the side leaves. Draw *l m* $\frac{1}{2}$″ above *e f*, and through points *l m* draw verticals, as shown.

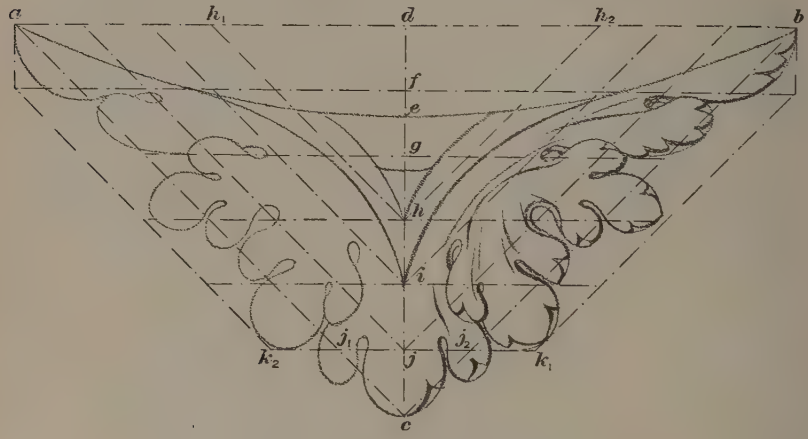

FIG. 18

FIG. 19

The whole figure can now be drawn in on the plate, by giving careful attention to the various points of contact with the guide lines in Fig. 17, and the direction and thickness of the lines in Fig. **7.**

45. In Fig. 8 is shown a drawing of a bronze furniture mount of the Louis XVI period in France. Great care must be taken, in drawing this example, to depict accurately the graceful flowing lines of the main details ; if these lines are not drawn properly the beauty of the design will be lost. The main construction lines for this figure are shown in Fig. 18, and are based on a triangle *a b c*, in which the side *a b* is 6″ long and the height *d c* 3″. The point *a* is set out on the drawing plate at a distance of $5\frac{1}{2}$″ from the left-hand border line and 4″ from the bottom border line.

46. Divide the line *c d* into six equal parts, as indicated by points *f*, *g*, *h*, *i*, *j*, and through these points draw horizontals. Also draw through points *h*, *i*, *j* lines parallel to *a c* and *b c*, such as $h\,h_1$ and $h\,h_2$. Produce the horizontal $j_1\,j_2$ in both directions, and make $j_1\,k_2$ and $j_2\,k_1$ equal to $j\,j_1$. Through points k_1 and k_2 draw lines parallel to *b c* and *a c*, respectively. The main curve *a e b* of the ornament cuts the line *d c* at the point *e*. Having drawn in this curve, the main groups of leaves must be set out by means of the guide lines. After the general outlines have been inserted, which process is called *blocking in*, the sketch will appear somewhat as the left side of Fig. 18. When the blocking in is complete on both sides, the details of the leaves may be proceeded with, as indicated in the right side of Fig. 18, and the drawing finished as in Fig. 8.

47. In Fig. **9** is shown the drawing of a wrought-iron husk, taken from a balcony in the Palais de Versailles, France. The main construction lines for this detail are shown in Fig. 19 and are based on the square *a b c d*, having sides 4″ long, with *a d* parallel with and 5″ to the left of the right-hand border line, and *d c* parallel with and 1″ above the lower border line The main features of the design should be set out on the construction lines shown in Fig. 19, which are obtained by dividing the

square *a b c d* into smaller squares with 1″ sides. The drawing should be blocked in entirely before any attempt is made to draw in the details. With care there should be no difficulty in completing the drawing as shown in Fig. **9.**

The only remaining work to be done to complete this drawing plate is to draw in the title and the figure numbers according to the instructions given in *Geometrical Drawing*. To do this, draw two lines parallel to the top border line, $\frac{1}{2}$″ apart, and the top one $\frac{1}{2}$″ from the top border line. Commence the left-hand stroke of the L $7\frac{1}{2}$″ from the left-hand border line, the whole word occupying a space of 2″; then put your name, class letters, and number in the lower right-hand corner and the date in the lower left-hand corner, and send in the plate for correction.

DRAWING PLATE, TITLE: GEOMETRICAL ORNAMENT

48. In Figs. **1, 2,** and **3** are shown geometrical patterns used extensively in every kind of ornamentation. These types of ornaments are especially suited for textile products, for which they were originally devised. Subsequently the original textile designs have been varied so as to make them applicable to every other branch of the technical arts, and also in architecture as surface decoration. Figs. **1, 2,** and **3** are called *frets*, plain and interlacing, and were largely used in Grecian architecture and ceramic decoration. Fig. **5** is the same in principle as Fig. **3,** but the lines are curved instead of straight. Fig. **5** is termed a *guilloche*, meaning intertwining bands, and is suggestive of braided work. Both kinds are of countless variety, and with the addition of colours make beautiful ornaments. Their design is based on a network of squares, triangles, or circles, or combinations of these, and their character is such as to allow of strictly regular and unlimited repetition.

49. Figs. **1, 2,** and **3** may all be enclosed in rectangles 4″ long and 2″ high. Therefore, with the **T** square draw two horizontal lines across the plate at distances of $1\frac{1}{2}$″ and $3\frac{1}{2}$″, respectively, below the upper border line. Between these lines insert three

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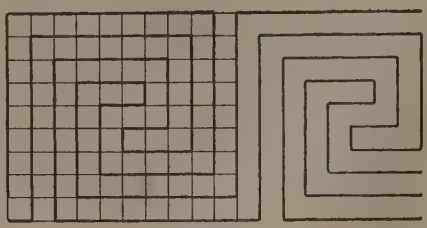
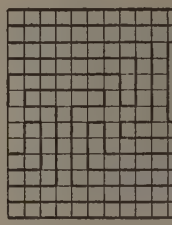


Fig. 1



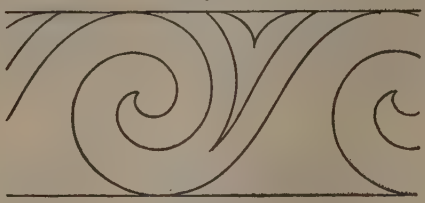


Fig. 4

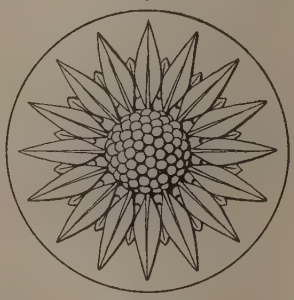


Fig. 7

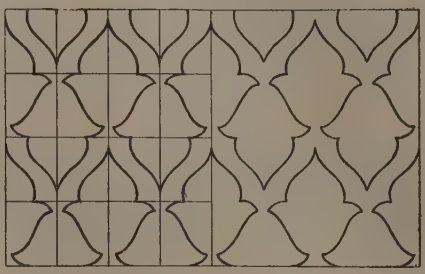


Fig. 10

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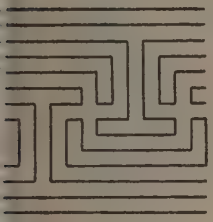

g. 2

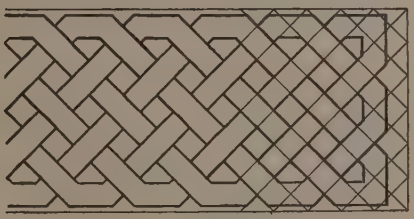

Fig. 3

g. 5

Fig. 6

g. 8

Fig. 9

g. 11

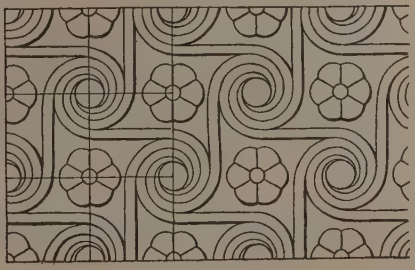

Fig. 12

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rectangles, the outer ones being $1\frac{1}{2}''$ from the adjacent border lines. There should be a space of $1\frac{1}{2}''$ on either side of the middle rectangle.

Beginning with Fig. **1**, divide its short side into nine and its long one into eighteen parts, and by means of the **T** square and set-square draw light horizontal and vertical lines through the division points, the result being a number of small squares. These lines are to serve as guide lines, while the ornamental lines are being inserted by freehand. The length of each line is found by counting the number of squares along which it extends, stopping carefully at the corners indicated in the pattern. Only the design itself should be inked in by freehand, not the guide lines. The latter should be erased, so that the finished drawing will appear as the right-hand part of Fig. **1**.

50. In Fig. **2** is shown a somewhat similar, but more elaborate, design than that shown in Fig. **1**. Divide the vertical side into thirteen equal divisions and repeat the same spacings horizontally for twenty-six divisions. Then draw through the points of division horizontal and vertical lines that will serve as guide lines while the figure is being drawn. The guide lines should not be inked in, but the whole drawing should appear as the right-hand part of Fig. **2**.

51. In Fig. 20 are shown the main construction lines necessary for the setting up of Fig. **3**. Divide line *a b* into six equal parts, and repeat the divisions horizontally along *a c* and *b d*. Through these division points on *a c*, *a b*, and *b d* diagonals should be drawn with a 45° set-square, to form a network of squares. Before beginning the figure it is necessary to draw some horizontal and vertical lines, such as *g h* and *e f*, through the points of intersection shown in Fig. 20. Thereafter draw the vertical

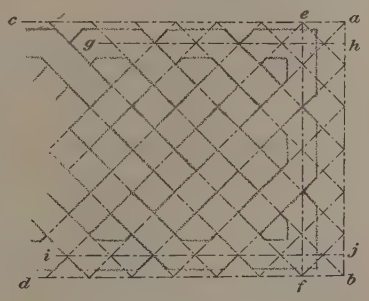

Fig. 20

parts of the bands, as shown, setting off from the centre line *e f*, on either side, one-half the width of a band. Then draw the horizontal parts of the bands on each side of lines *g h* and *i j*, as shown. The oblique bands are now drawn in by freehand, stopping carefully at the angles. It is needless to add that the inking in should be entirely by freehand without the use of a ruler. The guide lines should be erased after the drawing is inked in.

52. Figs. **4, 5,** and **6** may also be enclosed in rectangles, the positions of which may be fixed by drawing two horizontal lines at distances of 4″ and $5\frac{3}{4}$″, respectively, below the upper border line. Place the three rectangles between these lines directly below, and make them equal in length to Figs. **1, 2,** and **3.**

In Fig. **4** is shown an example of scrollwork ornament, distinctly Egyptian in style, and is used largely as a cresting or crowning feature of structural parts. It is a typical *running*

Fig. 21

ornament, that is, one in which the main lines are continuous and of a flowing character. Subsequently this ornament became a favourite in Greece, where it probably suggested the idea of the volute. To draw this figure, divide the side *a d*, Fig. 21, into three equal parts, and set off eight divisions, each $\frac{1}{2}$″ long, on the side *d c*; then draw the horizontal *a b* and other horizontal and vertical lines through the points of division. By means of these guide lines the ornament may now be drawn in the usual manner. The inking in must be done with great care, so as to obtain an even and correctly curved line.

53. In Fig. **5** is shown a form of guilloche ornament. It is similar in form to that shown in Fig. **3,** the lines being curved in the former ornament instead of forming angles. Divide the sides *a b* and *b d*, Fig. 22, into halves and draw the lines *g h* and *c f*. Set off the points *m* and *o* $\frac{7}{32}''$ from *a* and *c* and draw the verticals *m n* and *o p*. Likewise draw the lines *i j* and *k l* at a distance of $\frac{1}{4}''$ above and below *g h*, and also lines *q r* and *s t* $\frac{5}{32}''$ below *a c* and above *b d*, respectively. Finally, divide the lines *m e* and *e o* each into four equal parts and draw the verticals, as shown. The bands may now easily be placed, and, if

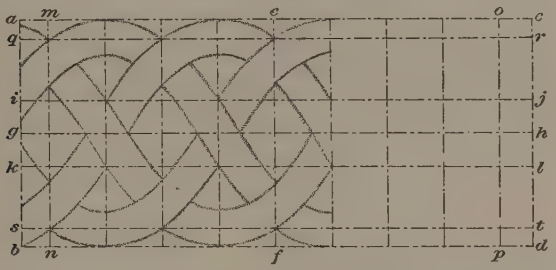

Fig. 22

correctly drawn, their width should be $\frac{9}{32}''$ throughout. It is preferable that the bands should first be drawn continuous in light lines, so as to ensure the correct curvature of the bands, and also that the continuations of the covered parts should be correctly placed. Subsequently, the visible parts of the bands may be strengthened by heavier pencil lines. The inking in of this exercise will require considerable care, as the outlines of the band must not alone be of the correct curvature, but the two outlines of each band must also be parallel throughout.

54. In Fig. **6** is shown a cyma from the Erechtheum at Athens, enriched with leaf decorations. A *cyma* is a curved moulding, with a reversed curve as its profile. Set off first the two narrow fillets at top and bottom of the moulding, each $\frac{7}{32}''$ wide, then measure off the other distances according to the dimensions given in Fig. 23. The outlines of each leaf *a b c* can then easily be drawn by observing closely at what points they

intersect the various guide lines. Particular care must be taken while drawing the pointed ends *b* of the leaves, in order that the halves of the leaf may be symmetrical and that the junctions of the lines at this point may be neatly done. It is also necessary that the curves at *c* that join two leaves should be smoothly drawn and that they should pass over gracefully into the curves

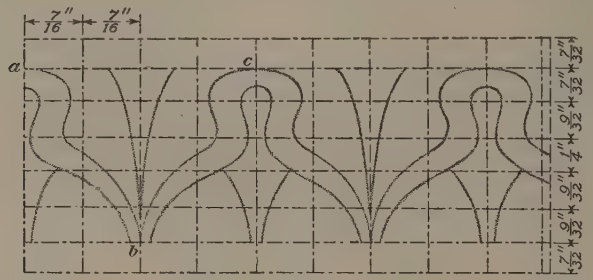

FIG. 23

that form the sides of the leaves. The curves are shown closer together at *c* from the fact that the moulding curves toward the rear at the top, thus causing the leaves to appear foreshortened at these places. These remarks apply also to the inking in of the figure, when particular care must be taken to avoid contact between the lines at *b* at either side of the centre line.

55. The outlines of Figs. **7, 8,** and **9** are circles. For the purpose of arranging them symmetrically, draw a horizontal line across the plate at a distance of $5\frac{3}{8}''$ above the lower border line. On this line fix the centres of the outer circles at a distance of 3″ from the adjacent border lines, and place the centre of Fig. **8** midway between those of Figs. **7** and **9.** For Figs. **7** and **8,** draw circles with a radius of $1\frac{3}{8}''$; the circle for Fig. **9** is made with a radius of $1\frac{1}{32}''$.

In Fig. **7** is shown an English brass furniture mount of eighteenth-century design, the construction lines for which are shown in Fig. 24 (*a*). Divide the circumference of the circle first into eight equal parts and then subdivide each of these into four parts; next draw lines from each of the division points to the

centre of the circle. These radial lines will form the centre lines of the main leaves, and of the subsidiary leaves below them. For the purpose of making all the main leaves of the same length, a smaller circle is drawn with a radius of $1\frac{1}{4}''$, at which these leaves will terminate. In a similar manner circles of $\frac{15}{16}''$, $\frac{11}{16}''$, and $\frac{13}{32}''$ radius must be drawn to determine the end points of the subsidiary leaves, the widest parts of the main leaves, and the boundary of the rosette centre, respectively.

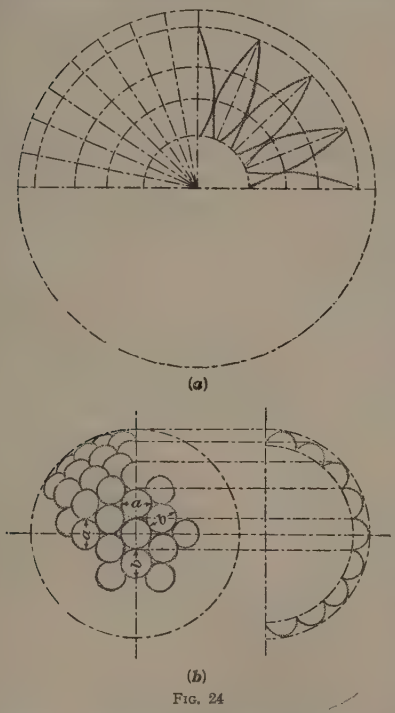

FIG. 24

56. Some difficulty will be found in drawing the central part with the small circles in such a manner that their arrangement and variation in size will give the right effect. It is not intended that a perfect copy shall be made of Fig. 7, but the general effect should be the same. For the purpose of showing how the effect is produced, an enlarged view is given of this part in Fig. 24 (*b*), which is an elevation and a section. In the latter view the semispheres of the rosette are arranged on the outside of a large semicircle, and if projectors are drawn from the sectional view to the elevation, it is seen at once that the diameters *a*, placed tangentially to a circle passing through the centres of similarly placed semispheres, will be of the same length for all the circles, representing the outlines of these semispheres, but the diameters *b*, measured radially, will become

more and more foreshortened as the circles to which they belong are farther away from the centre of the elevation. The result is, that only the circles near the centre of this view are true circles ; the others will assume more and more an elliptical form and will also be more covered by the circles nearer the centre.

57. In Fig. 24 (*b*) the circles near the centre have been placed with their centres along concentric circles of gradually increasing diameters. The general scheme of the arrangement has been indicated, and also the elliptical form that the outer circles assume. It is not intended that this arrangement shall be closely followed on the plate, but a general idea should be kept in mind as to the cause of the effect produced.

58. In Fig. 8 is shown a rosette of thirteenth-century design, taken from the cloister at Mont-Saint-Michel. It is more difficult to draw than that shown in Fig. 7, but if the main lines of the centres of the leaves are first drawn in, and then the main

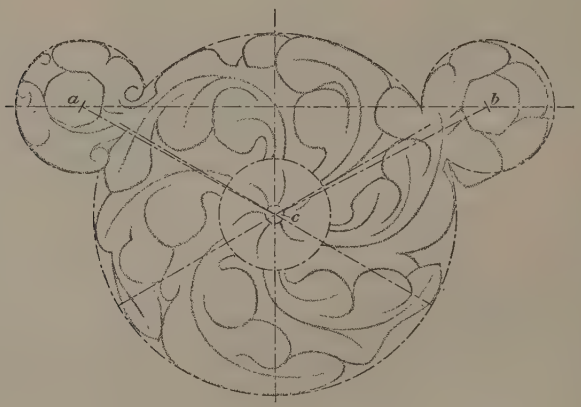

FIG. 25

shapes of the leaves are blocked around these lines, no difficulty should be found in filling in the detail. The ornament can be set up on the basis of three circles whose centres are at the three points of the triangle *a b c*, shown in Fig. 25.

59. Draw the side $a\,b$ at a distance of $\frac{3}{16}''$ above the centre c, already fixed. With radii of $1\frac{1}{16}''$ and $1\frac{3}{16}''$ draw small arcs, with c as a centre, intersecting line $a\,b$ at a and b, respectively. With a and b as centres describe circles with radii of $\frac{1}{2}''$, these circles serving as boundaries for the small rosettes. The main rosette can be divided into six groups bounded by radii; therefore, divide the circle into six parts, as indicated. Next proceed to insert the principal veins of the large leaves, and around these block in the main parts in the manner shown in Fig. 25. Then the other details may be inserted.

The inking in of the shaded outlines of this ornament requires particular attention. It is noticed that there is not a single line of uniform strength throughout. The outlines, in particular of the leaves, show a constant and often rapid change in thickness. This character of the lines should be studied very carefully and great pains should be taken to produce the same effects. There is a peculiar life and character in the drawing, combined with a certain general softness, that it would be difficult to obtain by any other means.

60. In Fig. **9** is another form of rosette, from the Capitol Museum at Rome, the construction lines for which are shown in Fig. 26. Before beginning the drawing, describe two circles of $\frac{5}{8}''$ and $\frac{9}{32}''$ radius, respectively, as boundaries of the central ornament. Divide the circumference of the largest circle into twelve equal parts and draw lines through the points of division to the centre, as shown. The detail can now be filled in from Fig. **9**. The remarks made in Art. **59** about the variation in strength of the ink lines apply also to Fig. **9**.

FIG. 26

61. In Figs. **10, 11,** and **12** are shown three examples of diaper work, generally applied to stonework in which the face is often worked into squares or lozenges, with a leaf or other ornament therein. Fig. **10** is a counterchange diaper pattern, and Fig. **12** is a Theban wall diaper, while Fig. **11** is of an encaustic floor tile taken from St. Mary's Church, Salshurst. To set out these designs, draw two lines across the plate, parallel to the lower border line and at a distance of 1″ and $3\frac{1}{2}$″ from it, respectively. Figs. **10** and **12** are rectangles, 4″ long and $2\frac{1}{2}$″ high, each placed at a distance of 1″ from the adjacent border line. Fig. **11** is enclosed in a square, with sides $2\frac{1}{2}$″ long, its centre being vertically below that of Fig. **8.**

62. The construction lines necessary for drawing Fig. **10** are shown on the plate. First divide the upper side of the rectangle into eight equal parts and one of the vertical sides into four parts. Then draw through the division points vertical and horizontal lines. Only one-half of Fig. **10** is divided in this manner. The design can now be completed by studying the left-hand side of Fig. **10** and noticing where the various lines of the design cut the construction lines. The construction lines will not be inked in, as in Fig. **10,** but will be rubbed out when the drawing is complete.

63. To draw Fig. **11,** first divide the square already drawn into four smaller squares, as shown, dividing the figure up into four similar tiles. All of these squares are then divided into sixteen squares each by construction lines, but two only are shown divided in the drawing. The construction lines of all the squares are to be rubbed out when the inking in of the figure is complete, and not shown as in Fig. **11.** The circles forming the basis of the design in each of the four squares may be described in pencil with the compasses, but the inking in must be by freehand. Great care should be taken to make the stems of the leaves in each corner of the square tangential to these circles.

64. In drawing Fig. **12** begin by dividing the side *g j* into three equal parts *g h*, *h i*, and *i j*, as shown in Fig. 27. Along

the upper side $g\,f$ set off $g\,k$ equal to $g\,h$ and repeat these divisions five times, the last division coming at f. The right-hand side of the rectangle, as shown in Fig. **12,** extends only to the line $e\,e$, but because of the necessity of having a complete repetition of the pattern at that end, it is necessary to extend the rectangle to $f\,f$ in pencil. The drawing is inked only to line $e\,e$, and the

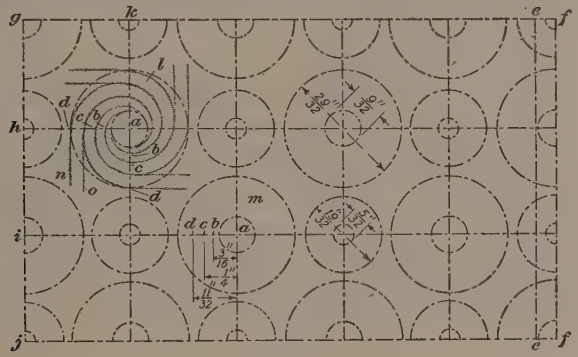

Fig. 27

part beyond is erased. Draw verticals through the divisions of the upper side, thus obtaining fifteen squares in which to place the elements of the design. At the points of intersection of the vertical and horizontal lines set off a series of circles with the diameters given, and in the order shown in Fig. 27.

65. The most difficult part of this exercise is the drawing of the spirals shown at l, Fig. 27. To facilitate the drawing of these parts it is necessary to have recourse to measurement, such as may be obtained by means of a strip of paper. For this purpose set off along one edge of the strip four points a, b, c, d, at distances as given along the diameter of circle m, Fig. 27. These four points, now copied on the strip, are set off along four radii, as shown in the circle l, thereby obtaining points symmetrically arranged around the centre a. This operation is repeated with all the large circles in the rectangle. The points, thus determined, indicate the places where the spirals cross the horizontal and vertical guide lines, and will therefore be of great

assistance in drawing the curves. But there will still be some difficulty in giving the lines the correct curvature, and great care must be taken to obtain this result.

It will be noticed that straight and parallel lines, such as at *n* and *o*, Fig. 27, connect each set of spirals with adjoining sets. The correct placing of these lines will be rather difficult, if the remainder of the drawing is not correctly made. Special instruction for completing the small rosettes will not be necessary.

66. The real difficulty in this exercise is met with when the inking in begins. Most of the lines are not only curved, but they are also in many cases parallel. Some of them are light and others heavily shaded; in the latter case the difficulty is further increased. The important point to aim for is the production of clean lines, that is, lines that are evenly rounded and, wherever required, of uniform strength without ragged and heavy places. The central circles, as at *a*, and those in the small rosettes, must all be inked by freehand. The boundary lines of the figure may be made by means of a ruler; but otherwise the work should be all freehand. There should be no guide lines shown in the finished drawing on the plate.

67. Before drawing in the title, carefully look over the drawing plate and compare it with the original to see if in any way the work can be improved. Commence the title by drawing two parallel lines $\frac{1}{2}''$ and $1''$ below the top border line, respectively, and start the lettering at a point $3\frac{3}{4}''$ from the left-hand border line, so that the last letter will come at a point about $3\frac{1}{2}''$ from the right-hand border line. Fill in the date in the lower left-hand corner and your name, class letters, and number in the lower right-hand corner, and send in the plate for inspection and correction.

DRAWING PLATE, TITLE: ENRICHED MOULDINGS

68. In this plate are shown eight distinct types of Greek and Roman enrichment to mouldings. It is probable that the Greeks were the first to classify their mouldings systematically,

ENRICHED MOULDINGS

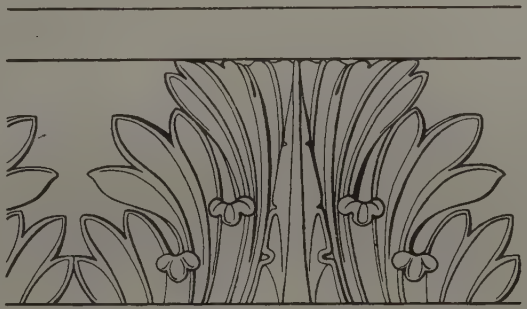

Fig. 1

Fig. 2

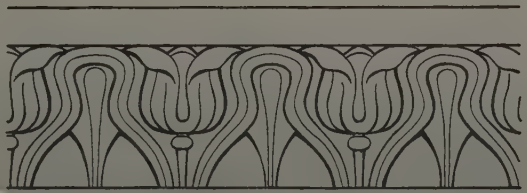

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Fig. 3

Fig 5

Fig. 6

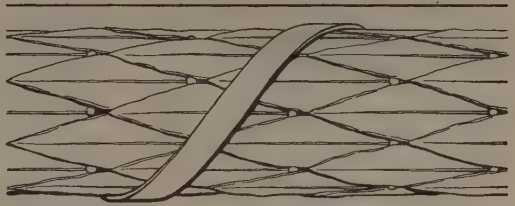

Fig. 7

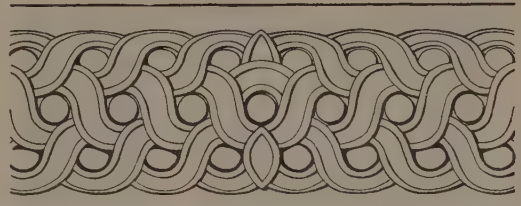

Fig. 8

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and to use the combination of a few simple forms to secure the most artistic effects. The original outlines of their mouldings were probably drawn freehand, but in all cases they approximate closely to the curves of the conic sections. When they were carved or enriched, the form of decoration usually corresponded in outline to the curve of the moulding itself. Thus, the ovolo moulding is enriched with the egg and dart, as in Fig. **6** ; the torus, in Fig. **8**, is enriched with the guilloche, or a reed ornament, as in Fig. **7**, all indicating in the elevation in a general way the cross-section of the ornamented moulding.

69. Before beginning these exercises, it is preferable first to draw a series of horizontal lines between which the various examples may be symmetrically arranged. Four lines enclosing the first four exercises are drawn at distances of $1\frac{1}{2}''$, $4\frac{3}{4}''$, $6\frac{1}{4}''$, and $8\frac{1}{4}''$, respectively, below the top border line. The

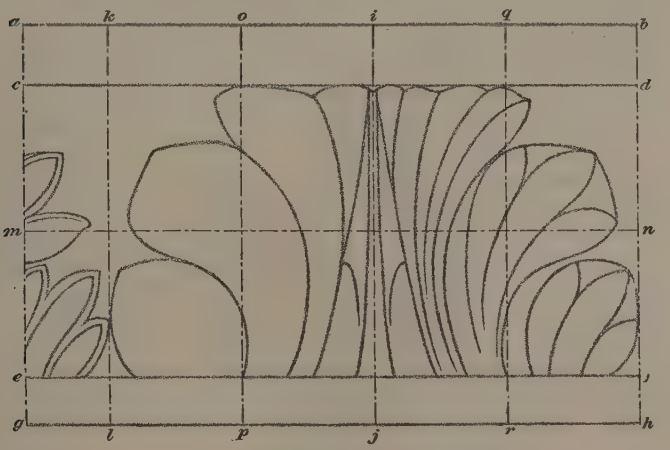

Fig. 28

remaining lines are drawn at distances of $7\frac{1}{4}''$, $5\frac{1}{4}''$, $3\frac{3}{4}''$, and $1\frac{1}{2}''$, respectively, above the bottom border line. Draw vertical lines at distances of 1″, 6″, 7″, and 12″, respectively, from the left-hand border line fixing the positions of the exercises laterally.

In Fig. **1** is shown a Roman ornament frequently used for decorating cyma mouldings. In form it is a type of the acanthus leaf, and one that in its conventionalized form plays an important part in ornamental design. Draw *c d*, Fig. 28, $\frac{1}{2}''$ below *a b* and *e f* $\frac{5}{8}''$ above *g h*. Set off from *a* a distance *a k* equal to $\frac{11}{16}''$, and divide the space *k b* into halves at *i*, then draw the verticals *k l* and *i j*. Subdivide the spaces thus found by lines *m n*, *o p*, and *q r*. The construction lines necessary are now complete, and the main features of the design may be blocked in, in a manner similar to that shown in the rectangle *k i j l*, Fig. 28. Great care must be taken with these main lines to give them the graceful curve and swing found in the original and to give them the proportions of the drawing in Fig. **1**.

70. Having carefully blocked in the main masses, they can be divided up to a certain extent, but no notice must as yet be taken of the accurate outline or detail of individual leaves. The graceful curves of the lines forming the leaves must first be obtained, and no more detail should be inserted than is shown in the rectangle *i b h j*, Fig. 28. When these lines have been sketched in correctly, the original must be carefully studied, and the detail put into the drawing. Only by this means of working up from masses can a really satisfactory result be obtained. Having completed the detailed outline of the figure on the left side of the centre line *i j*, the portion of the figure repeated on the right side of *i j* may be put in in outline from a tracing made of the corresponding piece on the left-hand side of *i j*.

71. To make this transfer, procure a piece of tracing paper and draw on it two lines corresponding to *c d* and *i j*, Fig. 28, and lay it over the finished drawing so that these lines coincide with those on the drawing. Carefully trace with a soft pencil as much of the outline of the finished drawing to the left of *i j* as is required to be reproduced to the right. Now lay the tracing paper with the outline on it face downwards on the drawing plate, so that the lines *c d* and *i j* again coincide with similar lines on the drawing. The traced part will now be to the right

of the centre line *i j*. While the tracing is now held securely with the left hand, it is rubbed over by the right hand with a hard polished object, such as the handle of a knife. As the lines on the tracing are facing the plate, the lines will by this process be transferred to the latter and the design will appear in soft outlines, which may be used as a foundation for the right-hand half of the design. Care must be taken not to rub this outline, as it will easily smudge the paper. If a line is made on this tracing so as to coincide with *b h*, then the part to the left of *k l* may also be transferred by letting the line *b h* on the tracing coincide with *k l* on the plate.

72. In Fig. 2 is shown an ornament taken from a Greek cyma moulding from the pediment of the temple of Apollo, Bassac. The method of setting up the construction lines for drawing this figure is shown in Fig. 29. Set off the construction lines at the

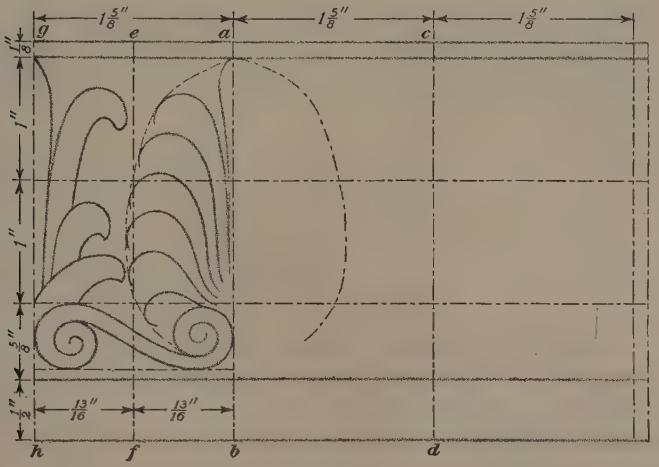

Fig. 29

distances from the top and bottom boundary lines given in this figure; also the vertical guide lines. Then proceed with the drawing by first blocking in the outline of the main parts, as shown by the dotted lines in Fig. 29. Then draw in the main

lines of the leaves, which are at first drawn only in single lines so as to obtain the direction and position of the various points. When this has been done the scrolls underneath may be drawn in, merely in general outlines at first, so as to get their direction, after which the whole may be shown more in detail and finished. When the part to the left of line *a b* has been finished in outline, it may be transferred to the right side of *a b*, as explained in Art. **71**, and then also to the right of line *c d*. What was said in Art. **66** with reference to the inking in of the ornaments applies in particular to the examples on this plate.

73. In all the designs on this plate the tracing-paper method, mentioned in Art. **71**, may be used for copying those parts of a design that are constantly repeated, as, for instance, the part that is included between the lines *c d* and *g h*, Fig. 29. This part is called a *repeat*. It is not always necessary to trace the whole of a repeat; very often it consists of two symmetrical halves, as in Fig. 29, where the part *a b d c* is the reverse of the part *a b h g*. In that case only one half of the repeat, such as *a b h g*, need be traced, and then reversed in the manner described.

74. In Fig. **3** is shown the ornament on a Roman cyma reverse moulding from the forum of Trajan, at Rome. Fig. **4**,

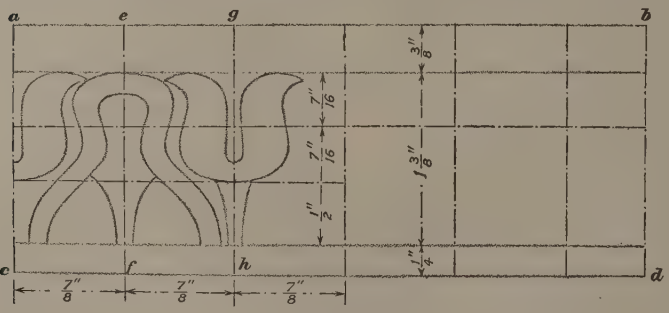

Fig. 30

which is similar in design, is a Greek cyma reverse moulding from the Erechtheum at Athens. The construction required

for the setting out of these designs is given in Figs. 30 and 31, and no instructions, additional to those previously given, are

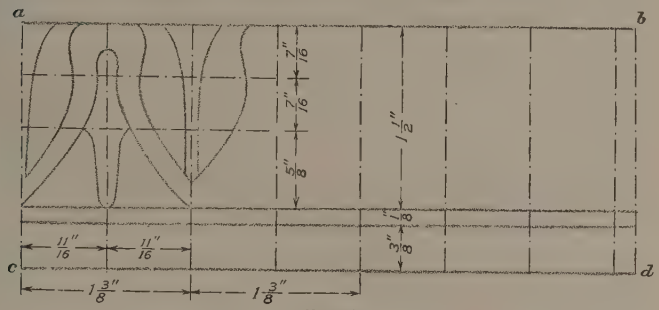

Fig. 31

here necessary. It is understood that full advantage is taken of the possibility of tracing parts of the ornaments.

75. In Figs. **5** and **6** are shown two forms of ornament very common on the ovolo moulding. In Fig. **5** is the Roman ovolo moulding ornament, called the *egg-and-tongue*, from the temple of Mars Ultor, Rome, and in Fig. **6** is the Grecian *egg-and-dart* ornament from the Erechtheum at Athens. The setting out of the construction lines necessary for these two drawings is shown in Figs. 32 and 33.

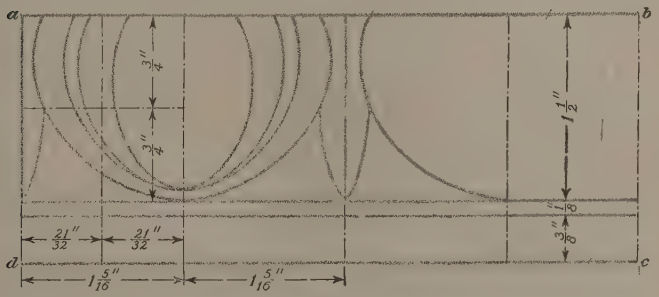

Fig. 32

76. In Fig. 32 it will be seen that the centre lines of the eggs and the tongues are set off parallel with *a d* and at distances of $1\frac{5}{16}$" apart. In Fig. 33 *e f* is set off parallel with *a d* and at

a distance of $4\frac{5}{8}''$ from it. The space $a\,e$ is then divided into eight equal parts and verticals are drawn through the points so found, determining the centre lines of the eggs and the darts.

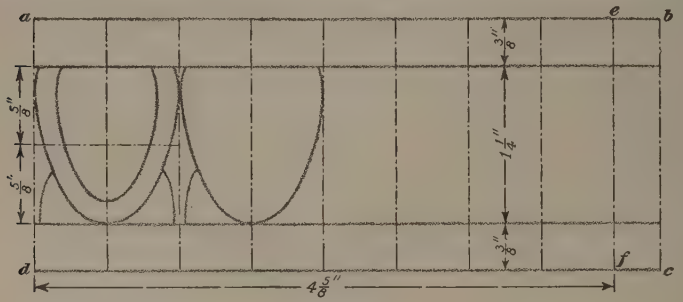

Fig. 33

After the horizontal lines bounding the eggs and darts have been drawn in, the main lines and the details can be drawn.

77. In Figs. 7 and 8 are shown two forms of torus moulding enrichment. Fig. 7 is a Roman torus enrichment, and Fig. 8 is a Greek enrichment from the Erechtheum at Athens. In Figs. 7 and 8 the mouldings themselves are semicylindrical;

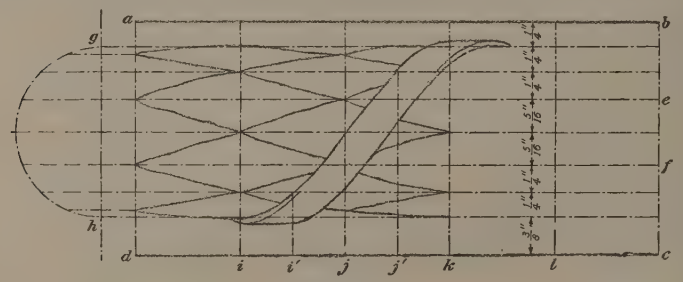

Fig. 34

consequently, the ornamental elements are shown foreshortened near the top and bottom. The construction lines necessary for the setting up of Fig. 7 are shown in Fig. 34. Divide $a\,b$ into five equal spaces of 1″ each by vertical lines at i, j, k, l.

In Fig. 34 the stems of the leaves are arranged at equal distances over the surface of the semicylindrical torus. The

exact positions of these centre lines can therefore be found by means of the semicylinder shown at the left, which represents a transverse section, of Fig. 34. For this purpose the curve $g\,h$ is divided into eight equal parts, as shown, and horizontal lines drawn from the points of division across the torus. These lines are then used as centre lines for the leaves.

The band represented as winding round the torus follows the curve of a helix, and its outlines may therefore be determined by means of the semicircle $g\,h$ in the usual manner. For this purpose, the spaces $i\,j$, $j\,k$, etc., have to be subdivided by lines at i', j', etc. The points of intersection between these verticals and the projectors from $g\,h$ are points on the helix.

78. When beginning the exercise, Fig. **7**, the leaves should first be blocked in, as shown in Fig. 34, and when the main lines have been found the details can be added. Great care must be taken in drawing these details so as to avoid any appearance of heaviness and stiffness.

In Fig. **7** this result has been obtained by indicating the outlines of the leaves by lines of a peculiar light and wavy character. In order that this effect may be still more increased and the outlines made more indefinite and of a greater variety, they have at some places been indicated by double lines, of which the inside ones are broken lines. The drawing has been executed with a certain freedom and abandon that must be reproduced in the finished drawing. It must not be understood, however, that this apparent freedom can be obtained by a careless drawing. On the contrary, considerable skill is necessary to obtain the desired results, but the effect should be such that both the art and the effort required are concealed. Freedom in drawing is obtained only after long practice and careful attention to details.

79. The guilloche ornament shown in Fig. **8** may be drawn by means of the guide lines shown in Fig. 35. Draw the vertical $e\,f$ centrally between $a\,d$ and $b\,c$. Set off on both sides of $e\,f$ seven equal parts $\frac{11}{32}''$ wide, and through the points so found draw verticals $g\,h$, $i\,j$, etc. Draw horizontal lines through the points found by setting out the figured dimensions in Fig. 35, and the

construction lines for the figure will be complete. The points found by the crossing of the vertical and horizontal lines will be important points on which the lines of the ornament may be set out.

80. Commence the drawing of the ornament by putting in the circles whose centres are at the intersections of the vertical lines *i j*, *g h*, etc., with the centre line *k l*. These circles are $\frac{9}{32}''$ in diameter, and may be struck in with the compasses. The whole of the rest of the figure must be drawn in freehand, first setting up the main lines as shown in Fig. 35. After these have been made as nearly correct as possible, the details are filled in. It will be sufficient if one repeat of the figure, as enclosed, for

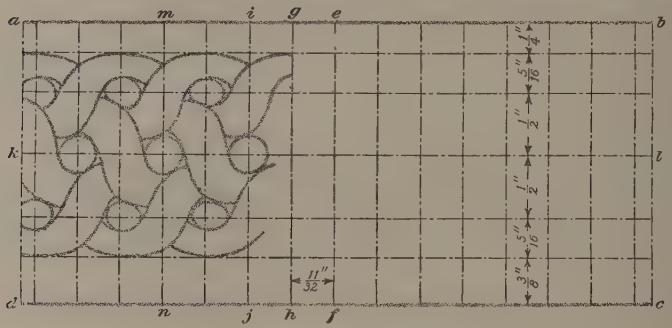

Fig. 35

instance, by the rectangle *i j n m*, is drawn, first by freehand. This can then be traced, and repeated as many times as may be required to complete the design, after the manner described in Art. **71.**

To avoid too many duplications of the repeat, it may be preferable to draw two repeats by freehand, and then duplicate both in one operation. Great care must be taken that the first repeat is correctly drawn, because if any inaccuracy occurs in one, it will be reproduced by tracing throughout.

81. The pencil setting out on this plate is now complete and it may be inked in. This operation must be performed with great care and the results repeatedly compared with the original

BOMBAY

CONVENTIONAL FOLIAGE

Fig. 1.

Fig. 2

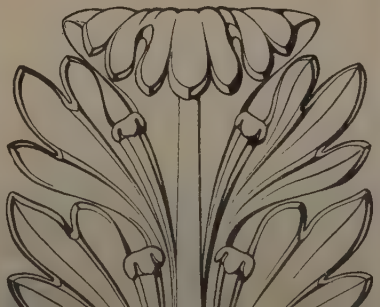

Fig. 3

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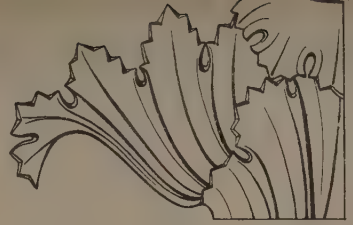

Fig. 4

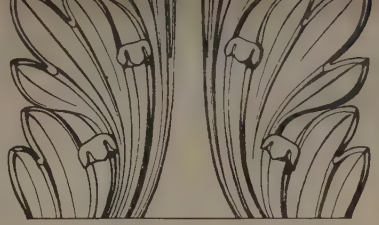

Fig. 5

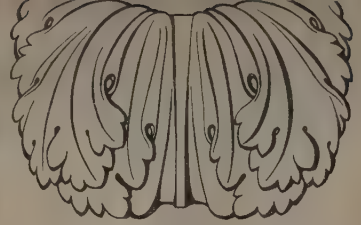

Fig. 6

Fig. 7

Fig. 8

Fig. 9

in every detail. It should constantly be kept in mind that the ornamentation is distributed over a semicylindrical surface, and that the parts, therefore, must be correctly foreshortened as they approach the upper and lower borders. Draw two lines parallel with and $\frac{1}{2}''$ and $1''$, respectively, below the top border line for the title, and commence the lettering $2\frac{1}{4}''$ from the left-hand border line, leaving a similar space between the last letter and the right-hand border line.

DRAWING PLATE, TITLE: CONVENTIONAL FOLIAGE

82. Commence work on this plate by drawing in the border lines, as before, and then parallel with the top border line, and $1\frac{1}{2}''$ below it, draw a light pencil line right across the plate. This line will give the top boundary lines of Figs. **1**, **2**, and **3**. Mark off along this line, commencing from the left-hand border and each time measuring from it, spaces of $1''$, $4\frac{3}{8}''$, $6\frac{1}{2}''$, $8\frac{5}{8}''$, and $12''$, and draw perpendiculars through the points so found. The perpendiculars will form the right and left vertical

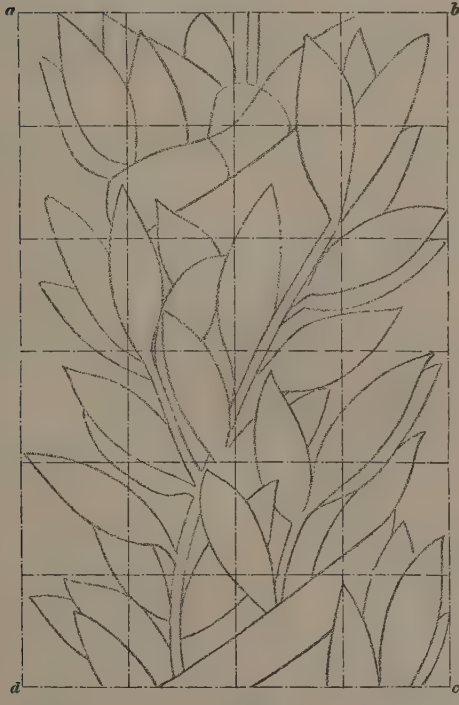

FIG. 36

boundaries of Figs. **1** and **3**. On the remaining one the centre of the circle enclosing Fig. 2 should be placed at a distance of $3\frac{1}{8}''$ below the top border line.

83. Commence the drawings on this plate with Fig. **1**, and draw in the lower line of the ornament $6\frac{13}{16}''$ below the top border line. This example is taken from a cast and represents a very good type of French conventionalized leaf ornament. The necessary construction lines are shown in Fig. 36, where the rectangle, already drawn, is shown to have its side *a b* divided up into four equal divisions and the side *b c* into six divisions. As before, the main outlines of the leaves must be drawn in first, and the position and direction of the main stem. Then the detail may be filled in by carefully copying Fig. **1**. The remarks made in Art. **78** regarding the production of a certain kind of delicate and wavy outline apply in particular to this example.

84. In Fig. **2** is shown a drawing of a bronze furniture mount of French design of the period of Louis XVI. It may be enclosed in two circles, struck from the centre that has already been fixed. The outer circle must be described from this centre with its circumference tangent to the top boundary line for Figs. **1**, **2**, and **3**, already drawn. The inner circle has a radius of $\frac{31}{32}''$. An intermediate circle with a radius of $1\frac{9}{32}''$ serves as a guide in drawing the central stems. The blocking in of the leaves is shown in Fig. 37, and their positions on the band formed by the three circles can easily be determined by drawing on the plate

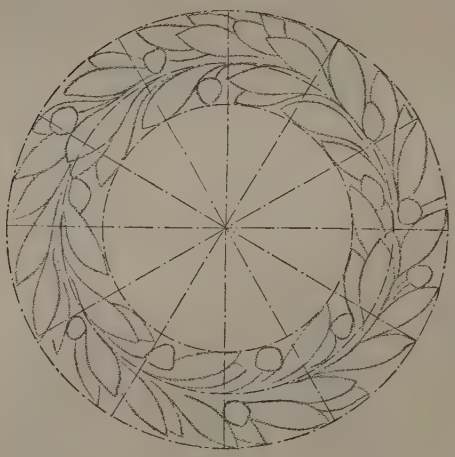

FIG. 37

horizontal and vertical diameters to the circle, and also lines running through the centre at angles of 30° and 60° to the horizontal, as shown in Fig. 37.

85. In Fig. **3** is shown another example of French running ornament. It is a conventional treatment of the oak of the Louis XVI period. The top and side border lines of this figure have already been found, and the lower border line completing the rectangle may be drawn in line with the lower border line of Fig. **1.** Divide this rectangle into twenty-four smaller rectangles, as shown in Fig. 38, and proceed to block in the outlines of the leaves, noting carefully where they cut the various construction lines.

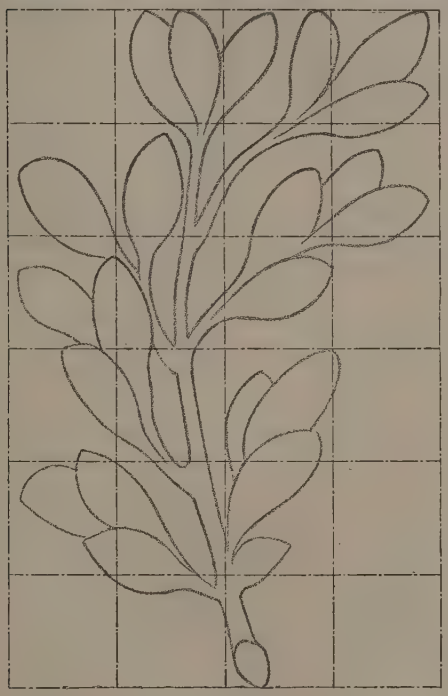

Fig. 38

86. The construction lines for Figs. **4, 5,** and **6** are shown in Figs. 39, 40, and 41, and may be drawn in, making the lower boundary line *a b* in each case parallel with and $6\frac{1}{8}''$ above the bottom border line. The line *a b*, Fig. 39, is made $3\frac{1}{3}''$ long, with the point *b* $4\frac{3}{8}''$ to the right of the left-hand border line; the rectangle *a d c b* has its vertical sides $2\frac{1}{4}''$ long. One side and the base of the rectangle are divided into four equal parts, and through the points so found horizontal and vertical construction lines are drawn

as shown in Fig. 39. The figure represents the corona of a Greek stele.

87. In Fig. **5** is shown a drawing of a Roman acanthus leaf from the temple of Jupiter Stator. Its centre line coincides with that of Fig. **2**, produced. Only one half of this figure needs to be drawn, as, for instance, that to the left of the centre line in Fig. 40. The other side of the figure may be reproduced by means of a tracing. In Fig. 40, where the construction lines of the figure are shown, the centre line $a\,b$ is made $5\frac{1}{2}''$ long. The line $b\,c$, Fig. 40, has already been drawn on the plate. The dimensions for setting out the remaining construction lines are shown in Fig. 40.

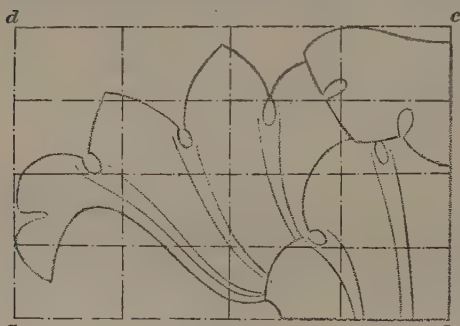

FIG. 39

88. In Fig. **6** is shown the overlapping part of a leaf, taken from a Roman candelabrum; the construction necessary for drawing one half of the leaf is shown in Fig. 41. After one side of this figure is drawn in carefully, the other side can be reproduced by tracing it. The line $a\,c$, Fig. 41, is drawn on the plate $3\frac{3}{8}''$ long, with the point c $\frac{5}{8}''$ to the left of the right-hand border line; $a\,b$ is $2\frac{1}{4}''$ high. The remaining horizontal and vertical construction lines are drawn in, as shown in Fig. 41, by dividing one of the horizontal and vertical sides into three and four equal spaces, respectively, and drawing vertical and horizontal lines through the points so found. These guide lines will suffice for the insertion of the main lines.

89. Fig. **7** is the drawing of a boss from Lincoln Cathedral, Fig. 8 a finial from Saint Chapelle, Paris, and Fig. **9** a French wrought-iron scroll in the Victoria and Albert Museum. It is desired to ascertain how far the preceding work of this Section

has been understood; therefore, no instructions will be given for the drawing of these exercises. But as the exercises on the specimen plates, furnished with this Section, are smaller than those to be made on the drawing plates, it follows that the proportions of the ornaments shown on the specimen plate cannot be followed directly. It will therefore be necessary to enclose Figs. **7**, **8**, and **9** on the specimen plate in three rectangles, the dimensions of which will be the overall dimensions of the ornaments.

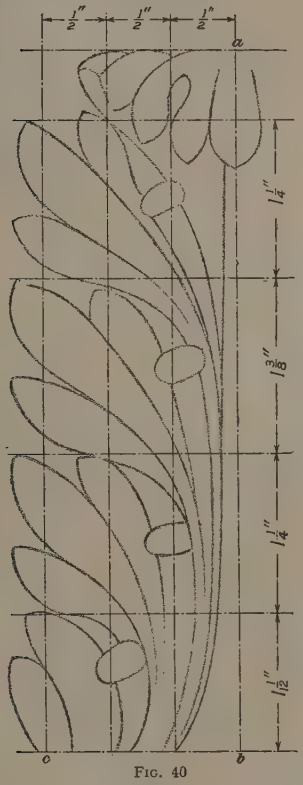

Fig. 40

90. The dimensions of these rectangles and the positions they should occupy on the drawing plate will be found in the following manner: Draw a horizontal across the plate at a distance of $\frac{7}{8}''$ above the lower border line. At points $1''$ and $4\frac{3}{4}''$ from the left-hand border line, erect on this horizontal two verticals each $3\frac{1}{2}''$ long and connect their upper ends by a horizontal, thus completing a rectangle $3\frac{3}{4}''$ by $3\frac{1}{2}''$ which is to enclose Fig. **7**. Draw another horizontal across the plate at a distance of $5\frac{3}{4}''$ above the bottom border line. Set off on the horizontal drawn first, points at distances of $5\frac{1}{8}''$ and $7\frac{13}{16}''$ from the left-hand border line, and two other points $1''$ and $4\frac{13}{16}''$ from the right-hand border line. Through these four points draw vertical lines between the two horizontal lines, thus defining two rectangles, one $4\frac{7}{8}''$ by $2\frac{11}{16}''$ and the other $4\frac{7}{8}''$ by $3\frac{15}{16}''$, which rectangles are intended to enclose Figs. **8** and **9**.

Having obtained the outside dimensions and positions of Figs. **7**, **8**, and **9**, proceed to insert in the rectangles, drawn on the specimen plate, such guide lines as may be found necessary and draw similar lines on the drawing plate. Then the blocking in of the principal parts may begin, and finally the drawing of the details. The title at the top is made in the usual manner.

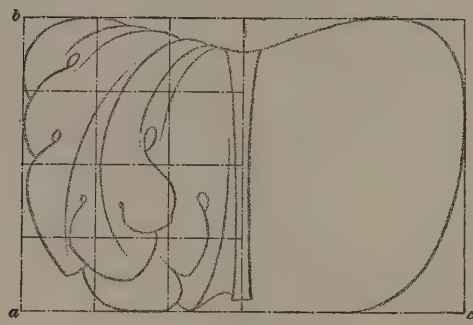

FIG. 41

DRAWING PLATE, TITLE: SCROLLS AND VOLUTES

91. In Fig. **1** is shown part of the ornament on an Ionic cap from the Erechtheum at Athens, and the construction lines necessary for the drawing of this figure are shown in Fig. 42. Draw the horizontal *a b*, Fig. 42, $1\frac{1}{2}''$ below the top border line, with points *a* and *b* 1″ and $7\frac{1}{2}''$ to the right of the left-hand border line. Draw *e f* parallel to *a b* and 3″ below it, and *d c* $\frac{3}{16}''$ below *e f*. Draw the verticals *a d*, *g h*, and *j k* $2\frac{9}{16}''$ apart. Divide the sides *a e* and *a g* of the rectangle *a g i e* each into three equal parts, and through the division points draw horizontal and vertical lines, thus forming nine similar rectangles, in which the boundary lines will serve as guide lines while the main lines of the figure are being inserted.

92. After the centre lines of the leaves and scrolls have been set out, as shown in Fig. 42, the detail can be quite easily filled in. It is not necessary to draw in more of Fig. **1** than half of one repeat, as shown in Fig. 42, as, when this portion has been completed, it can be traced and reproduced on the other side of the centre line *g i*, as previously explained. In a similar

SCROLLS A

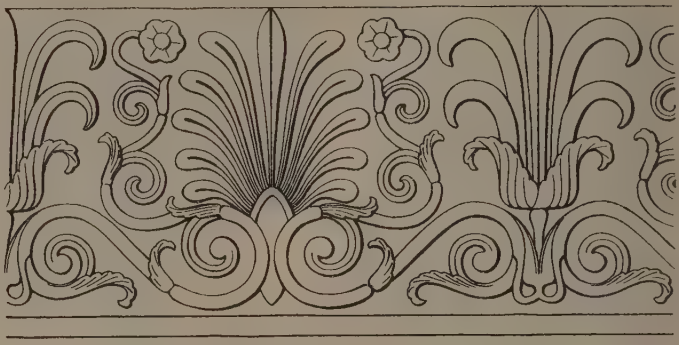

Fig 1.

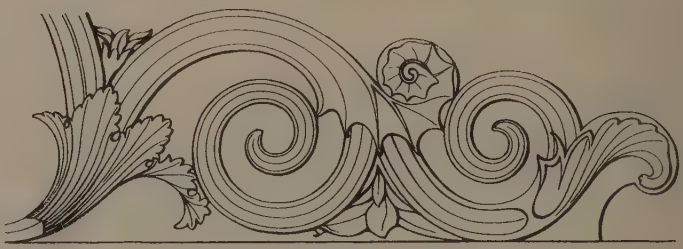

Fig. 3.

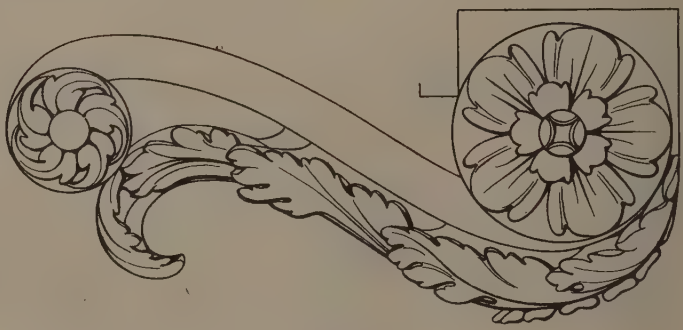

Fig. 4

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ND VOLUTES

Fig 2

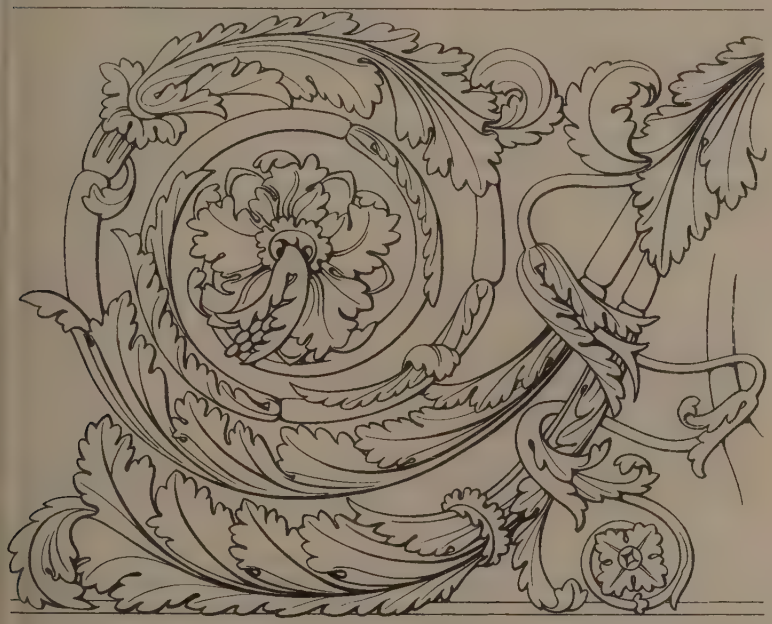

Fig. 5.

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manner the detail on the right-hand side of the centre line *j k* may be put in from the tracing.

93. In Fig. 2 is shown a part of the ornament from the Palais Negroni, Via delle Botteghe, Oscure · it is a type of

Fig. 42

running or repeating ornament often used in design. The construction lines necessary for the setting up of this figure are shown in Fig. 43, and should be set out on the plate by drawing *a b* at the same distance from the top border line as line *a b* in

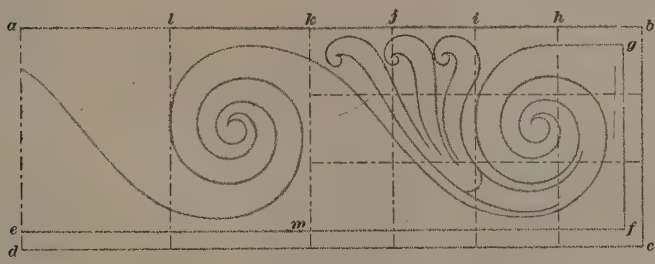

Fig. 43

Fig. 42. The points *a* and *b* in Fig. 43 are $8\frac{1}{2}''$ and $1''$, respectively, to the left of the right-hand border line. Draw the line *c d* $2\frac{11}{16}''$ below *a b*, and lines *e f*, *f g* parallel to *d c* and *c b* and $\frac{7}{32}''$ away from them. Set out along *b a*, from *b*, spaces *b h*, *h i*, *i j*, and *j k*, each equal to $1''$, and draw verticals through

the points so found. Draw a vertical through l $3\frac{11}{16}''$ to the left of the point i. Divide the line $k\,m$ into three equal parts and draw horizontal lines through the points so found.

94. The construction lines are now complete, and the lines of the figure may be drawn. The scroll formed between the verticals at k and l may be reproduced by tracing the scroll to the right of the vertical at i. The vertical at l corresponds exactly in its position relative to the scroll to the vertical at i, and can be used as a guide line on which to lay the tracing so as to place the scroll in the correct position.

95. Great care must be taken when inking in the examples on this plate, as the long and sweeping curves found in all of the examples are more difficult to execute than anything on the preceding plates. It is a good practice to lay a sheet of tracing paper over the pencil outline and ink in the long curves several times on the tracing paper before commencing work on the plate. By this means freedom of movement of the hand is obtained, and the final drawing is not spoilt while these exercises are being carried on.

96. In Fig. **3** is shown a scroll ornament taken from the top of the Choragic Monument of Lysicrates at Athens. In setting out the outlines of the central wavy stem, care must be taken that

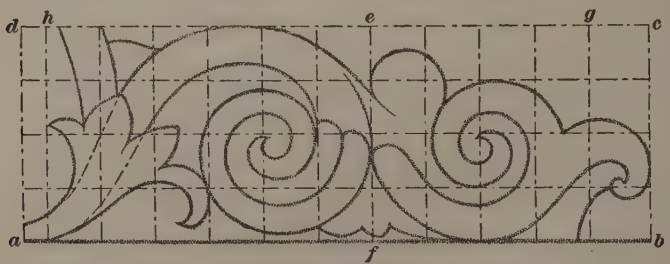

Fig. 44

the scrolls which branch off from it do so tangentially. Fig. 44 shows the guide lines necessary for this figure. The line $a\,b$ is first drawn on the plate 5″ above the lower border line, with the

points *a* and *b* 1″ and $7\frac{1}{2}$″, respectively, to the right of the left-hand border line. On *a b* construct a rectangle *a b c d* with vertical sides $2\frac{1}{4}$″ long. On completing the rectangle, the enclosing lines for the figure will be complete.

97. To obtain a number of points on the scrolls by means of which they can be drawn, divide *d a* into four equal parts and draw through the points of division horizontal lines as shown. Set off point *e* on line *d c* at a distance of $3\frac{5}{8}$″ from *d*; then from *e*, toward *g*, set off four divisions, and from *e* to *h* six divisions, each equal to $\frac{9}{16}$″. Through each of these division points draw verticals, leaving spaces at *d h* and *g c* that differ in width from the others.

While this pencil drawing is rather difficult, the finishing in ink will be found still more so. This is because the fine lines in the scrolls must be smooth curves of even thickness. Particular care must be taken with the veins in the leaf at the left end, so as to give them the correct shading and at the same time keep the thick ends separate.

98. In Fig. 4 is shown a modillion ornament from the Palazzo Strozzi, Florence, the construction lines for which are shown in Fig. 45. Set out on the drawing plate the rectangle

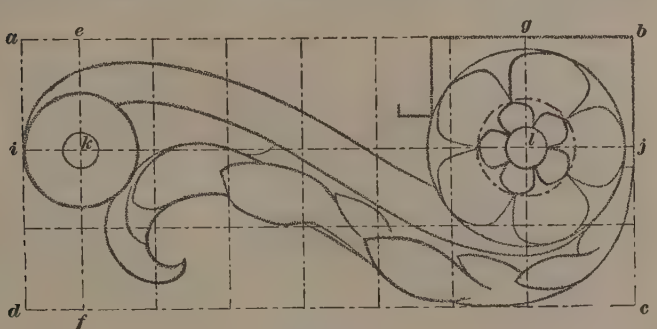

FIG. 45

a b c d, shown in Fig. 45, with sides $6\frac{1}{2}$″ and $2\frac{7}{8}$″ long. Place *d c* $1\frac{1}{8}$″ above the lower border line, and the point *d* 1″ from the left-hand border line. The points at the centres of the two

circles must first be found, and these circles may be struck with the compasses. Draw the vertical $e\,f$ $\frac{5}{8}''$ to the right of $a\,d$, and $g\,h$ $1\frac{1}{8}''$ to the left of $b\,c$. Then draw the horizontal $i\,j$ $1\frac{3}{16}''$ below $a\,b$. The points k and l, where $i\,j$ intersects $e\,f$ and $g\,h$, will be the centres from which the circles can be described.

99. With k as centre draw two circles with radii of $\frac{3}{16}''$ and $\frac{5}{8}''$, respectively, and with l as centre draw three circles with radii of $1\frac{1}{16}''$, $\frac{1}{2}''$, and $\frac{7}{32}''$. The main construction lines for the remainder of the figure must now be found. Bisect $i\,d$ and draw a horizontal through the point so found. Divide $e\,g$ into six equal parts, and through the points so found draw perpendiculars. With these guide lines the blocking in of the figure can be completed, as shown in Fig. 45, care being taken to make the main curves, that join the two circles, tangential to the circles at the points of junction.

100. In Fig. **5** is shown a very elaborate piece of ornament for a flat surface, taken from the marble frieze of the Villa Aldobrandi, Rome. This is very much more difficult to draw than any example previously given ; but if the main curves of the stems are set out accurately, and the centre veins of the various leaves are drawn tangential to them, a satisfactory result should be obtained.

101. In Fig. 46 is shown the construction lines necessary for the drawing of Fig. **5.** The base line $a\,b$ of the enclosing rectangle is placed 1″ above the lower border line, letting points b and a be 1″ and $8\frac{1}{2}''$, respectively, from the right-hand border line. Draw the verticals $a\,d$ and $b\,c$ each $6\frac{13}{16}''$ long, and join $d\,c$. A rectangle will then be formed enclosing the figure. The position of the centre i of the circle forming the centre, or *eye*, of the scroll must now be found. Draw horizontals $e\,f$ and $j\,k$ at distances of $\frac{1}{2}''$ and $4\frac{1}{8}''$ above the line $a\,b$, and a vertical $l\,m$ $4\frac{5}{8}''$ to the left of $b\,c$. The point i at the intersection of lines $j\,k$ and $l\,m$ will be the centre from which a circle with 1″ radius may be described. Set off along lines $j\,k$ and $l\,m$, on both sides of point i, several points 1″ apart; through the points thus found draw horizontal and vertical lines, which are to serve as guide lines.

102. The main lines of the curve forming the outside line of the main stem may now be drawn, first carefully marking on the guide lines the points where the curve cuts them. In a similar manner the other curves of the figure may be drawn, until a result is obtained similar to that shown in Fig. 46. The reason for commencing the figure in this manner is to obtain the easy flow and grace of the main lines. This result could not

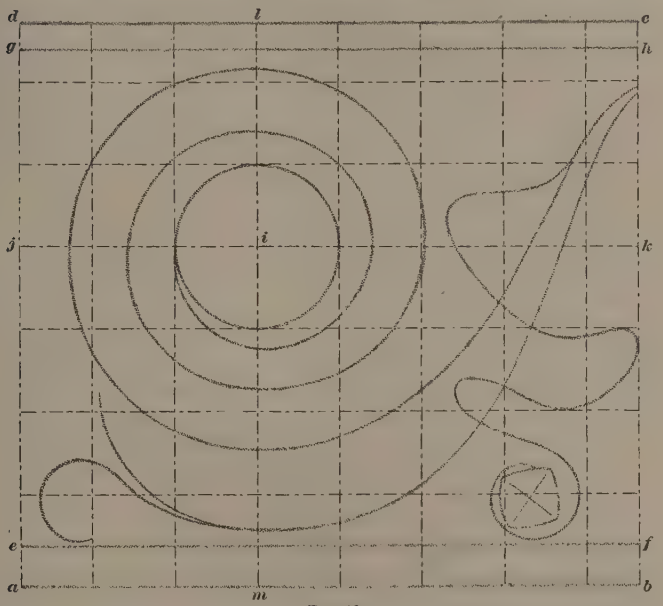

FIG. 46

very well be obtained in any other way than that shown; by this method the whole of the detail of the figure is kept subsidiary to these main lines, and is dependent on them. For the time being, the details must be ignored.

103. Having completed the main stems of the ornament, the outlines of the leaves must be blocked in, still omitting any unnecessary detail, such as the serrations of individual leaves. Masses only must be indicated, together with the

general direction and outline of each leaf. When this is completed, the drawing will appear as shown in Fig. 47, where it will be noticed that neither the detail of individual leaves nor any of the secondary veins are shown. The next step is to insert the veins, serrations, and centre lines of individual leaves,

Fig. 47

great care being taken that they are made tangential to the parent stem so as apparently to grow from it. Having completed the drawing so far, it may be examined in detail, comparing it step by step with Fig. 5. After this the final details may be added.

ADVANCED ARCHITECTURAL DRAWING

ARCHITECTURAL ORDERS

INTRODUCTION

1. In *Architectural Drawing*, the examples treated in the plates could be executed almost entirely with the instruments, and consisted of such plans and details as constitute the larger part of architectural office practice. The subjects treated in this Section will consist of architectural features that will involve both freehand and instrumental drawing, giving an opportunity of applying the practice acquired in freehand and ornamental drawing, and also serving as illustrations that show the application of ornament in architectural design.

The plates to be drawn are to be the same size as those of the previous ones, namely, 17 inches by 13 inches inside the border lines. No part of a drawing should be inked in before the whole drawing has been finished in pencil, as was explained in detail in *Architectural Drawing;* and all the dimensions, dimension lines, and headings should be shown, but the reference letters may be omitted.

DEFINITIONS

2. An **order** in architecture is the term applied to the combination of a column with its entablature. There are five of these orders, the Doric, Tuscan, Ionic, Corinthian, and Composite, each of which possesses distinguishing characteristics of

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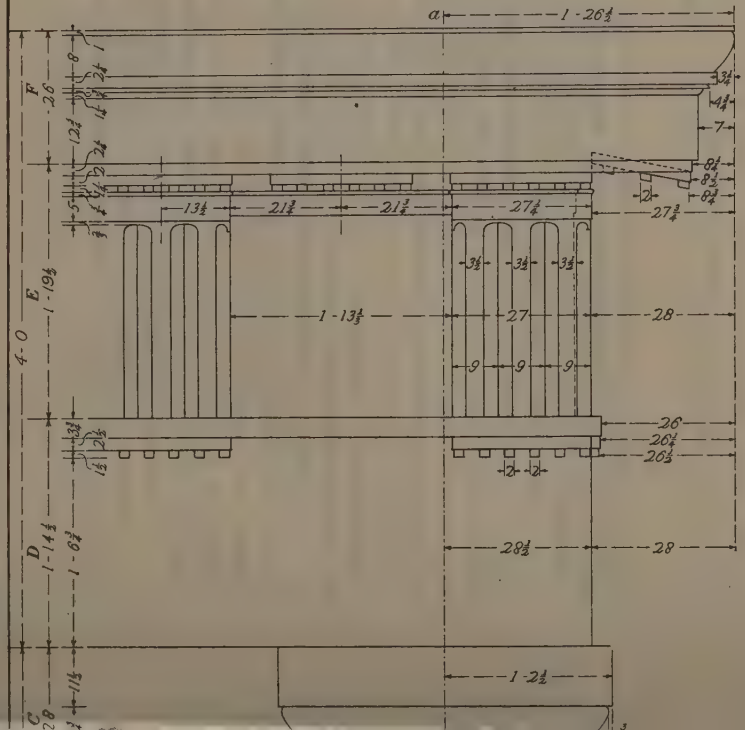
form and proportion, which will be pointed out in the explanation of the following plates, while the complete analysis of the orders and their details are given in *Architectural Design*, Part 1.

The Doric, Ionic, and Corinthian orders were originated by the Greeks and later on adopted by the Romans, who used them in a modified form. They also added two orders of purely Roman invention, namely, the Tuscan and the Composite. The plates in this Section are not arranged in chronological order. Instead of first describing all the Greek orders and then the Roman, each Greek order is followed by corresponding Roman modification. These five orders, or systems of proportion, are of the utmost importance to the architect, as they furnish him with a set of rules by which he may determine the relations that should exist between certain parts and details of a building. These rules are subject to slight variations in modern works, but are positive so far as their applications to the original orders are concerned.

3. All the orders consist essentially of two principal divisions, namely, the **column** and the **entablature.** They are usually mounted on a substructure which is so disposed as to distribute the load transmitted by the column over a larger area than is represented by the section of the base. In most Greek examples this substructure consisted of a series of steps that extended round the four sides of the temple, when it was known as the **stylobate.** In Roman architecture the substructure had the form of a wall, called **podium,** in which there was an opening at one end with steps to give access to the temple. The column consists of the **shaft,** or pier, which supports the superstructure, and is usually provided with an ornamental **base** and **capital,** which are details that differ widely in the several orders, as will be explained subsequently. The entablature is the superstructure proper. It consists of three principal divisions, called the **architrave, frieze,** and **cornice,** each of which serves a particular purpose, both structural and ornamental, as explained farther on.

As the three Greek orders were the original systems, it is suggested that particular attention be paid to the explanations

GREEK DORIC ORDER



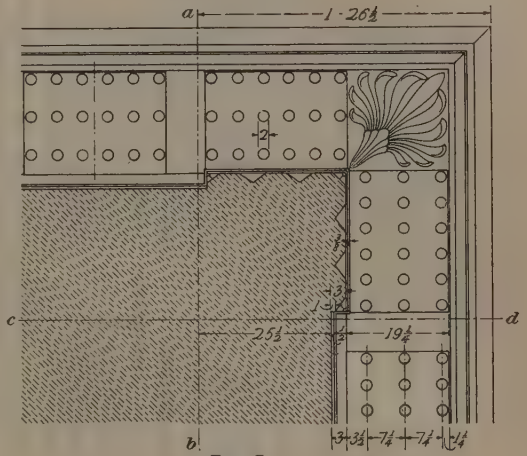
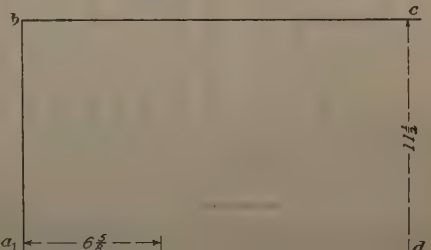


Fig. 5.



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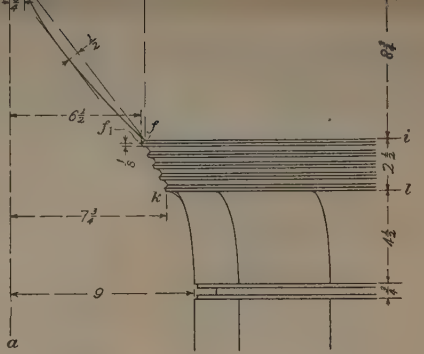


Fig. 2.

Fig. 4

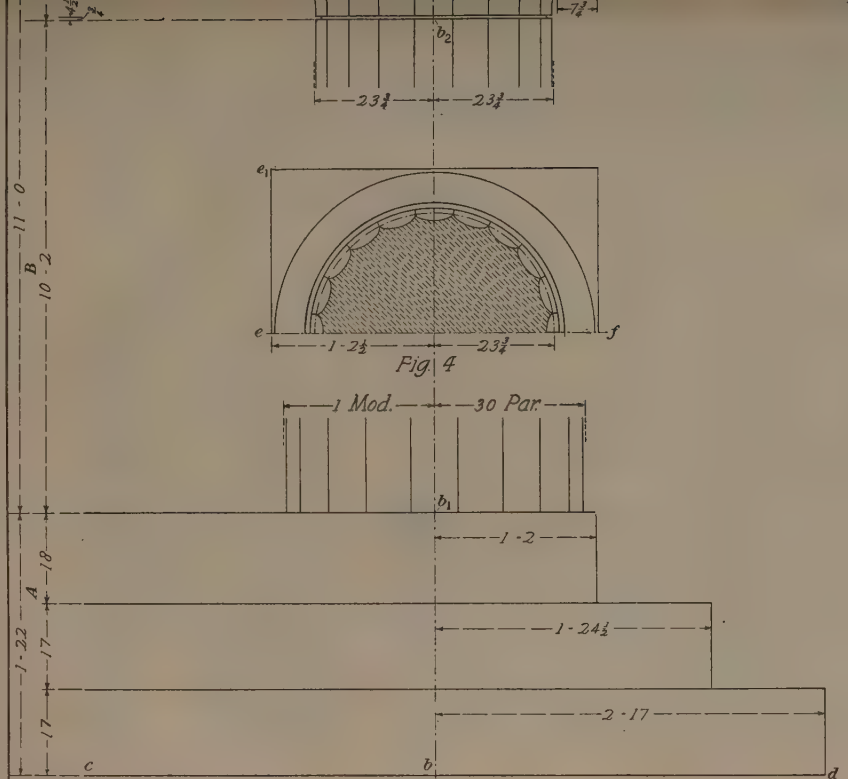


Fig. 3

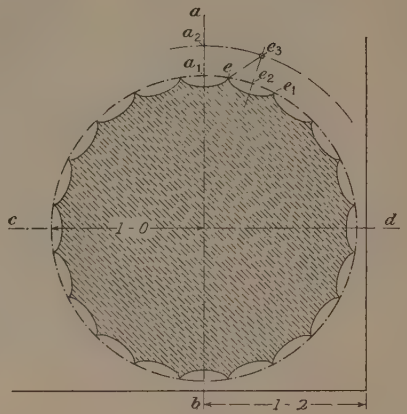


Fig. 1

given in the text, so that the drawing of the corresponding Roman orders and their details may be fully understood.

In order to distinguish readily between references to figure numbers on the drawing plates and to those in the text, the former will be printed in heavy-face type and the latter in ordinary type.

DRAWING PLATE, TITLE : GREEK DORIC ORDER

4. The Doric is the most ancient of the three Grecian orders, and represents the system of columnar construction in its simpler form. In Fig. **3** of this plate, *A* shows the stylobate of the order divided in three steps, so as to spread the foundation area of the structure. *B* is the shaft of the column, and *C* is the capital ; the Grecian-Doric column has no base. *D* is the architrave, which consisted in the early Greek structures of a number of lintels or stone beams extending from the top of one column to the top of the next. *E* is the frieze, which was occupied by a number of stone ceiling beams or flat slabs, which rested their ends on the architraves and formed the direct ceiling on the inside of the structure. *F*, the cornice, was the roof construction proper, and consisted of stone details built above the frieze to cover the ends of the roof beams and to provide a suitable finish to the eaves. The general effect of these details, when assembled in the complete order, is shown in the perspective view, Fig. 1. An enlarged view of the entablature is shown in Fig. 2, but both of these illustrations contain ornaments above the eaves and on the frieze that are not shown on the drawing plate.

The column of the order shown on this plate is drawn by means of the scale shown at the lower border line, but this scale is not based on any particular unit of length, such as a foot. Instead of this the diameter of the column is the governing measurement, and in architectural orders the members are proportioned in their ratio to the diameter of the column, according to an arbitrary scale of *modules* and *parts*.

5. Module.—The term **module** is a diminutive of the Latin *modus*, meaning " a measure " ; and in the architectural orders

the module is in nearly all cases equal to one-half of the diameter of the column. The module is divided into 30 subdivisions, called *parts*. In the following descriptions of the orders, the terms "modules" and "parts" will be abbreviated to "m." and "p.," in order that there may be no confusion with regard to the word "parts" when it is used in a more general sense.

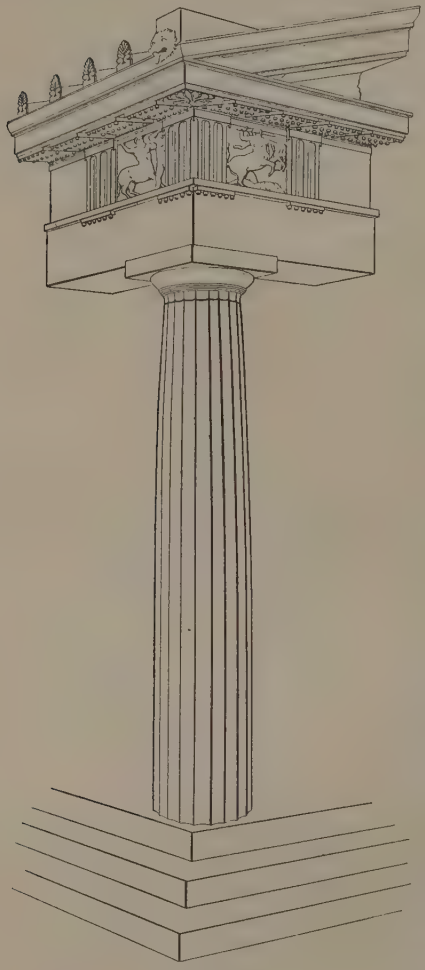


FIG. 1

By adopting the radius of a column as the length of a module, it follows that the orders shown on the drawing plates are without any definite dimensions. The drawings show only the relative sizes of the component parts. What the dimensions of these parts will be depends entirely on the length of the module adopted. If, for instance, the module is made equal to 1 foot and the diameter and length of the column are 2 and 14 m., respectively, it follows that the actual diameter is 2′ and the length 14′. Should, for the same column, a module 2′ long

be chosen, then the column would have a diameter of 4′, and it would be 28′ long.

6. Instructions for Drawing the Plate. — Begin this plate by constructing a scale of modules, as shown. At a distance of $1\frac{5}{16}''$ above the lower border line draw a line 6″ in length. Divide this line into 4 equal parts of 1 m. each, and subdivide the first part into 30 p., as shown. Now draw Fig. **1,** which is a plan of the shaft and stylobate; draw the lines of the upper step, each $\frac{3}{4}''$ from, and parallel to, the border lines. Draw *a b* and *c d*, the axial lines of the plan of the shaft, each at a distance of 1 m. 2 p. from the lines of the upper step of the stylobate, and with their point of intersection as a centre, and with a radius of 1 m., draw a circle defining the circumference of the shaft. The surface of the shaft is grooved perpendicularly by the 20 flutes, or channels, each of which is cut to an elliptic curve, as shown in the plan. The plan of the shaft must therefore be divided into 20 equal parts by lines radiating from its centre. Each pair of these lines will embrace one-twentieth of the circumference of the circle defining the plan of the column, or 18°, and the lines will pass through the **arrises,** or sharp edges projecting between the flutes.

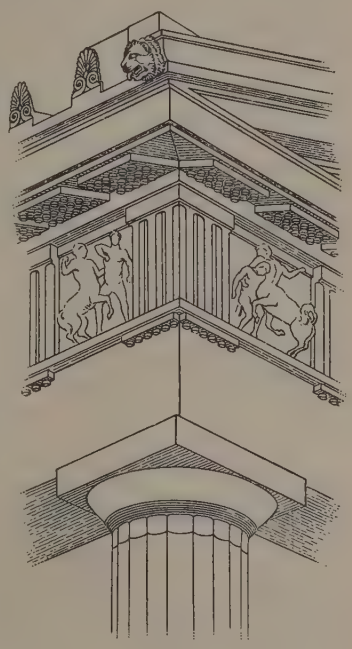


Fig. 2

7. If the plan of the column is drawn to a large scale, it will be necessary to draw the elliptic curves of the flutes approximately correct by using the construction shown in Fig. 3. At *a d b* is

shown the form of the flute at the bottom of the shaft, and at $a'\,d'\,b'$ the form of the same flute at the *necking*. By **necking** is meant the narrow part of the shaft adjoining the capital. Let $p\,q$ and $r\,s$ be the arcs of the lower and upper sections of the shaft, respectively, and set off accurately $a\,b$ and $a'\,b'$ equal to one-twentieth of the circumference. Draw the chords $a\,b$ and $a'\,b'$ and the centre line $m\,n$, cutting the chords $a\,b$ and $a'\,b'$ at c and c'. For the depth $c\,d$ of the channel at the base, divide $a\,b$ into 7 equal parts, and make $c\,d$ equal to one of these parts; for the depth $c'\,d'$ at the necking, divide $a'\,b'$ into 6 equal parts, and make $c'\,d'$ equal to one of these parts. The depth of the channel at the necking is therefore greater, in proportion to its width, than at the bottom of the shaft. To find the centres of the three arcs that compose the curve $a\,d\,b$, construct, on $a\,b$ as a base, the equilateral triangle $a\,o\,b$, and bisect the angles $a\,o\,d$ and $d\,o\,b$ by the lines $o\,e$ and $o\,f$. The point o will then be the centre of the arc $e\,d\,f$. Join $f\,b$, and at its middle point g erect a perpendicular $g\,l$, cutting $o\,f$ at l; the point l is the centre for the arc $f\,g\,b$; the centre k of the arc $a\,e$ is similarly found. The centres o', k', l' for the arc $a'\,e'\,f'\,b'$ are determined in precisely the same manner as described for the arc $a\,d\,b$.

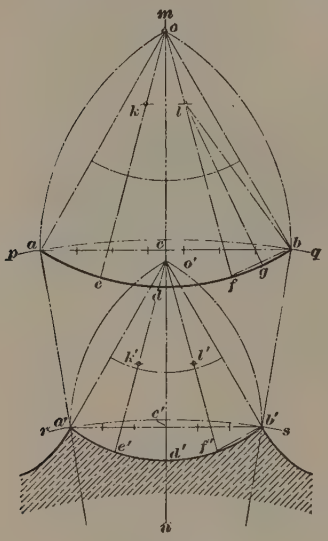


FIG. 3

8. By reason of the small scale to which the plan, Fig. **1**, is drawn, it will not be necessary to construct the curves of the flutes as in Fig. 3. A circular arc described in the following manner will suffice: Set off from point a_1 in Fig. **1**, a distance $a_1\,a_2$ of $\frac{9}{32}''$ and through a_2 describe a circle concentric to the shaft. Bisect the arc between each pair of arrises, such

as $e\,e_1$, at e_2 and through this point draw a radial line intersecting the outer circle at e_3; then, with e_3 as a centre and $e\,e_3$ as radius describe the arc $e\,e_1$. Repeat this construction for the other arcs.

9. Now draw Fig. **3**, placing the centre line $a\,b$ $4\frac{1}{4}''$ from, and parallel to, the left-hand border line, and at right angles to $a\,b$ draw $c\,d$, the bottom line of the stylobate, $\frac{3}{4}''$ above the lower border line; then set off from $c\,d$, on $a\,b$, the measurements of the principal divisions of the order and draw horizontal lines defining these divisions. For instance, set off on $a\,b$ from b to b_1 a distance of 1 m. 22 p. equal to A, the height of the stylobate. From b_1 to b_2 should now be set off a distance equal to 10 m. 2 p.; but as the size of the drawing plate is too small to contain the whole length of the shaft, only the top and bottom portions are shown. The shortened part B should be made $4\frac{7}{8}''$ long. The parts C, D, E, F are set off in the same manner. Set off on each side of $a\,b$, on the top step of the stylobate, 1 m. and dot the perpendicular lines defining the extreme diameter of the shaft, as shown. On the lower line of the architrave D set off on each side of $a\,b$ 1 m. $2\frac{1}{2}$ p., and draw perpendicular lines from the bottom of the architrave downwards until they intersect with a horizontal line drawn $11\frac{1}{2}$ p. below. These will define the elevation of the **abacus,** or square block on the top of the capital of the shaft. The diameter of the shaft is less at the top than at the bottom, and the sides of the shaft are curved in profile from the base to the neck of the capital; but, as the full length of the shaft is not shown, the method of profiling this curved outline will not be described at present. When the drawing of the Roman orders is explained, this curved outline of the shaft will be described, and the method of constructing it will be shown in detail.

10. Draw the outside, or return, lines of the architrave D and frieze E $28\frac{1}{2}$ p. to the right of the centre line $a\,b$. Then, 27 p. from the return line of the frieze, draw the perpendicular line defining the width of the **triglyph,** which is the ornamental block set in the frieze over each column and over each space between the columns. The triglyphs, in the early construction, consisted of the ends of the ceiling beams which rested on the

architrave. Draw this triglyph at the extremity of the frieze according to the measurements given, and duplicate it as shown, 1 m. $13\frac{1}{8}$ p. to the left. The space between two triglyphs is called a **metope,** and in nearly all examples of Greek architecture the metopes are filled with a carved slab. A slab is not shown on the plate, but two may be seen in Fig. 1. Immediately over the triglyphs and metopes are the **mutules,** with eighteen little drops, or **guttæ**, as they are called, on the under side arranged in three rows of six each. The mutules are not level on the soffit, but pitch upwards, as seen on the return of the cornice, where the mutule is shown in side elevation. These mutules represent the under side of the slanting roof beams as they existed in the early wood construction, and the guttæ are derived from the wooden treenails, or pins, which held these members in place. Draw the **corona,** which is the broad band of the cornice *F*, constituting its lower half. Above it draw the moulding called the **cymatium.**

11. Now draw Fig. **2**, which is an elevation of the details of the capital drawn to a scale 4 times that of Fig. **3** ; that is, 1 p. in this elevation is equal to 4 p. on the scale. Produce the right-hand side of the top step of the stylobate so as to serve as the right-hand limiting line for Fig. **2**, and draw $b\,c$, the upper line of the abacus, 6″ below the upper border line. Draw $a\,b$ at a distance of $4\frac{5}{8}$″ from the right-hand border line, and draw the lower side $a_1\,d$ of the abacus. For the purpose of drawing the profile of the **echinus,** the circular moulded part below the abacus, set off on $a_1\,d$ a distance $a_1\,e$ of $6\frac{5}{8}$ p. and draw the vertical $e\,f$ $8\frac{3}{4}$ p. long. Connect points $a_1\,f$ by a line $a_1\,f$ and bisect the latter. At the point of division erect a line at right angles and $\frac{1}{2}$ p. long. This line will give the height of the curve $f\,g$, which may now be drawn freehand, subsequently adding the curve $g\,h$. Draw the horizontal $f\,i$.

12. It is now necessary to draw a line that will define the positions of the outer faces of the **annulets,** or rings, round the neck of the capital. For this purpose draw a short line $f\,f_1$ at 45° to the horizon, intersecting at f_1 a vertical drawn at a distance of $6\frac{1}{2}$ p. from $a\,b$. Now draw $k\,l$ $2\frac{1}{2}$ p. below $f\,i$,

and draw another vertical $7\frac{3}{4}$ p. from $a\,b$ intersecting $k\,l$ at k. Draw a line $f_1\,k$, which will define the positions of the outer faces of the annulets. Complete the uppermost annulet by drawing a horizontal line through the point f_1 and a parallel line $\frac{1}{8}''$ below it, then divide the remaining part of the portion $i\,l$ into 4 equal parts. Now draw horizontal lines through the points of division to define the positions of the annulets. These annulets should project about $\frac{1}{4}$ p. from the surface of the echinus. Then complete the annulets as shown on the drawing plate.

13. The positions of the arrises on the necking cannot be found before the plan, Fig. **4**, has been completed. Place the centre line $e\,f$ of the latter at a distance of $5\frac{1}{8}''$ above the lower border line and draw the outline of the abacus according to the dimensions given in Fig. **3**. Draw the semicircle representing the upper part of the echinus with a radius of 1 m. $1\frac{3}{4}$ p., then the two semicircles indicating the largest and the smallest annulet with radii of 26 p. and $24\frac{3}{4}$ p., respectively. The semicircle in dash-and-dot lines of $23\frac{3}{4}$ p. radius passes through the points of the arrises in the plane at b_2, Fig. **3**. It is noticed in Fig. **4** that the arrises are extended beyond this circle to the smallest annulet, indicating that the arrises curve outwards from the plane at b_2 to this annulet, as clearly shown in Fig. **2**. The curves of the flutes, shown in Fig. **4**, may be drawn approximately by means of a compass, as follows: With a radius of 28 p. describe a semicircle on which the centres of the curves are to be placed. Fix the positions of these centres in the same manner as in Fig. **1**, and describe the arcs of the flutes with a radius of 6 p.

14. It is now possible to complete Fig. **2** by means of Fig. **4**. The line $e\,e_1$ in the latter view occupies a position relative to the centre of the column corresponding to that of the line $a\,b$ in Fig. **2**. Therefore, any distance measured from $e\,e_1$, enlarged 4 times and set off from $a\,b$ in Fig. **2**, will give the corresponding distance required. By this means the positions and curvatures of the arrises on the necking of Fig. **2** may be ascertained.

Now complete the capital of the column in Fig. **3**, drawing the echinus according to the method described for Fig. **2**. Project

the arrises directly from Fig. **4** to the neck of the column in Fig. **3** and project the lines of the flutes in Fig. **1** to the centre line *c d*, from which their spacing may be marked on a strip of paper and transferred to the lower part of the column in Fig. **3.** The dotted lines shown at the top and the foot of the shaft drawn at a distance of $23\frac{3}{4}$ and 30 p., respectively, each side of the line *a b*, represent the full diameter of the shaft at these places, that is, the distance between two arrises situated diametrically opposite each other. Now finish Fig. **3** entirely, and commence Fig. **5,** which is a plan of the cornice looking upwards, showing the soffit of the corona ; draw the axial lines *a b* and *c d* $3\frac{9}{16}''$ and $4\frac{3}{16}''$, respectively, from the border lines. Mark points fixing the positions of the various members of the corona, and draw lines defining them according to the measurements given in Fig. **3.** Then draw the triglyphs and guttæ.

DRAWING PLATE, TITLE: TUSCAN ORDER

15. This plate shows the elevation and details of the first of the Roman orders. There are five of these orders, and, although they vary materially from their Greek prototypes, they are similar to them in their principal characteristics. The Tuscan order, a perspective view of which is shown in Fig. 4, is the simplest of the five, and was probably, in its original form, an imitation of the Greek Doric. With the exception of the Tuscan and Ionic, the Roman orders are all much more elaborate than those of the Greeks, and in all five the stylobate is supplanted by a regularly designed pedestal on which the column stands. When supporting a row of columns, the pedestal is made continuous so as to form a podium. The mouldings of the Roman orders are always profiled with the arcs of circles, while the Greeks usually moulded their sections to the arc of a parabola or hyperbola. Other modifications exist in each order, which will be pointed out as they appear in the following plates.

16. In this plate the pedestal is shown at *A B C*, where *A* is the base, *B* the die, or body, and *C* the cornice of the pedestal. The base, shaft, and capital of the column are shown at *D*, *E*,

and *F* while *G*, *H*, and *I* indicate the architrave, frieze, and cornice of the entablature. Commence the plate by drawing a line 5″ long at a distance of $\frac{5}{16}$″ above the lower border line. Divide this line into 4 equal parts, each to constitute 1 m., and complete the scale in the usual manner. Then draw *a b*, the centre line of Fig. **1**, at a distance of $4\frac{1}{8}$″ from the left-hand border line. After drawing the base line *c d* at a distance of $\frac{3}{4}$″ above the lower border line, set off on *a b* the horizontal divisions of the order, according to the dimensions given on the plate. Draw the profiles of the mouldings on the capital and base of the column, and also at the returns of the entablature and pedestal, striking all the curves with a compass and from centres easily found by means of the various dimensions given on the plate.

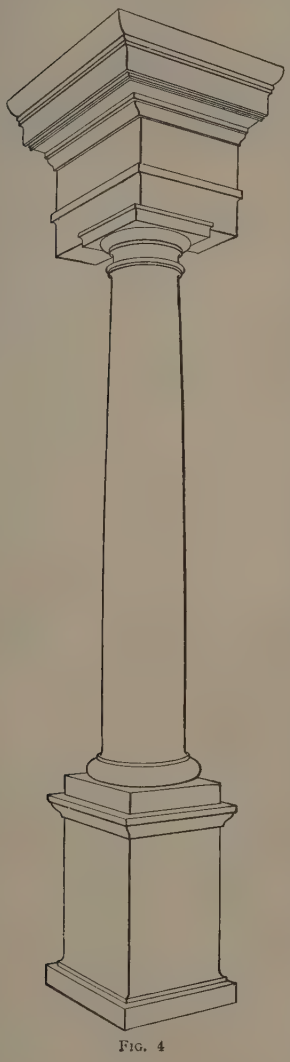


Fig. 4

17. Now draw Fig. **3**, which is a plan of the capital looking up, and Fig. **4**, a plan of the base, placing the vertical centre lines of these views at a distance of $2\frac{7}{8}$″ from the right-hand border line. The horizontal centre lines are drawn $8\frac{7}{8}$″ and $2\frac{7}{8}$″, respectively, above the lower border line. Draw the circular mouldings on the capital and base, in Figs. **3** and **4**, according to the proportions given in Fig. **1**, and complete these views.

Then draw the soffit, or under side of the cornice, shown in Fig. **2**. Place the vertical and horizontal centre lines $3\frac{5}{8}''$ and $4\frac{1}{4}''$ from the right-hand and the upper border line, respectively, and complete Fig. **2** from the proportions given in Fig. **1**.

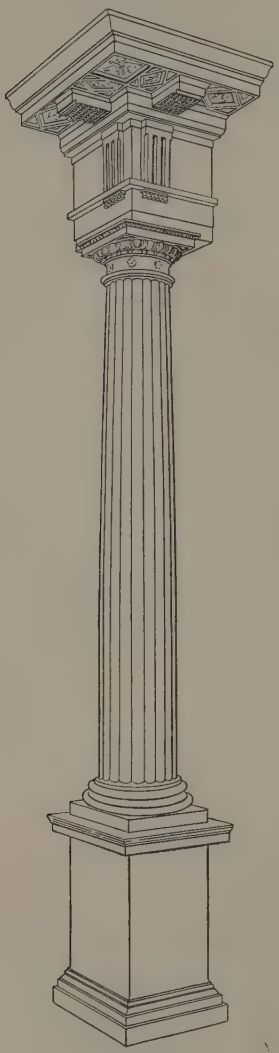
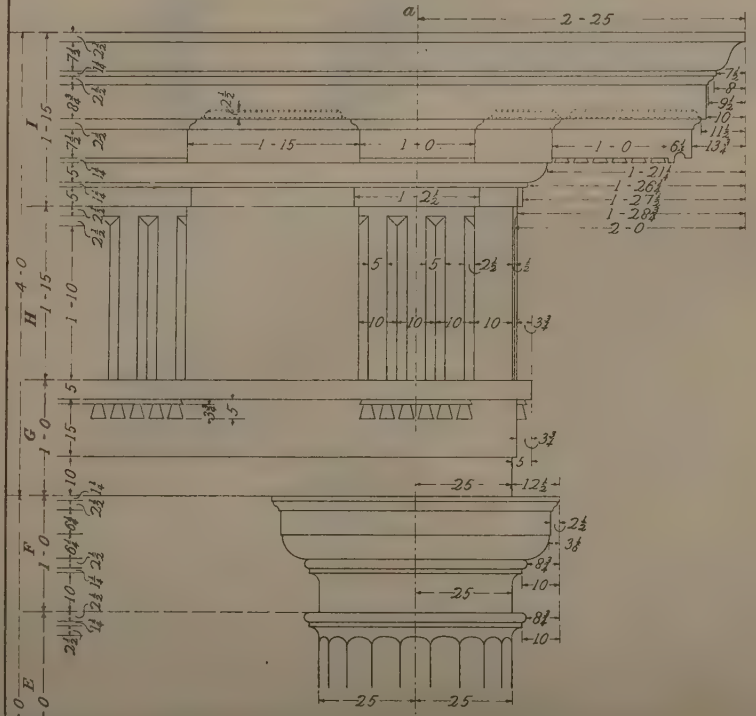


Fig. 5

18. Fig. **5** is a half elevation of the shaft of the column, showing the method of profiling the curved outline, or **entasis,** of the shaft. The purpose of the entasis is to prevent the shaft of the column from appearing too slender, and to destroy the optical illusion of concave sides, which is likely to appear when the lines of a shaft are parallel. As the size of the drawing plate will not allow this view to be drawn to the same scale as the other views, it will be necessary to reduce the size of a module for this view and to make it equal to $1''$ instead of $1\frac{1}{4}''$. Draw the centre line $e\,f$ at a distance of $5\frac{3}{8}''$ from the right-hand border line and make it 11 m. $19\frac{1}{2}$ p. long, this being the length of that part of the shaft which is to be provided with an entasis. Divide $e\,f$ into 8 equal parts and draw horizontal lines through the points of division, as shown on the plate. At f should now be drawn an arc $g\,h_1\,g_1$ with a radius of 1 m., which is one-half the lower diameter of the shaft. Make $h\,e$ equal to 24 p., which is the radius of the upper end of the shaft. From h draw $h\,h_1$

PUBLIC GIFT

DORIC ORDER



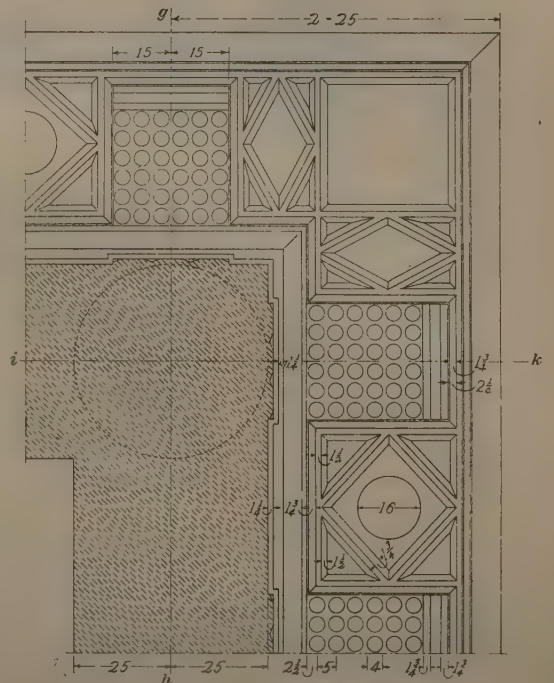


Fig. 2.

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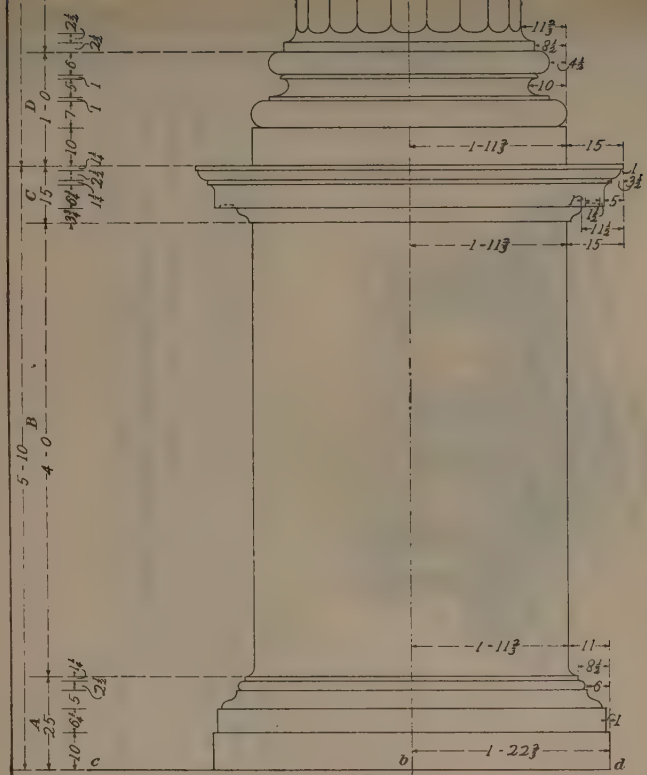


Fig. 1

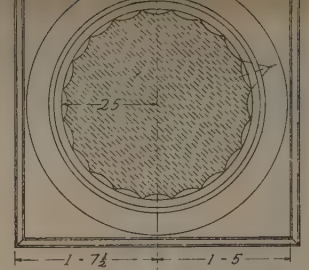


Fig. 3.

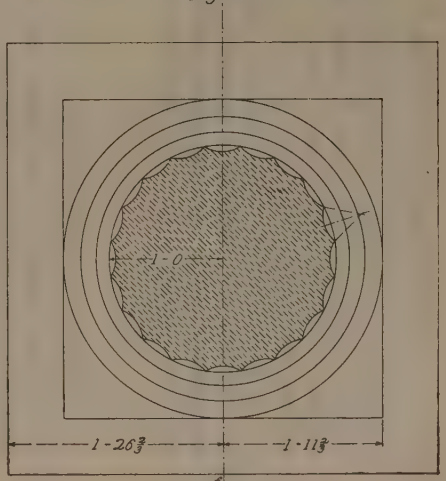


Fig. 4.

parallel to $e\,f$ and intersecting the arc $g\,g_1$ at h_1. Divide the arc $g\,h_1$ into 8 equal parts, as shown, and from each of these division points erect a vertical line to intersect the horizontal lines in the order shown on the drawing; that is, the line $h_2\,i$ intersects line $i\,i_1$ at i; line $h_3\,k$ intersects line $k\,k_1$ at k, and so on. Through the points of intersection h, i, k, etc., draw the curve of the entasis. Now finish the plate, inserting the dimensions and dimension lines, but omitting the reference lines.

DRAWING PLATE, TITLE: DORIC ORDER

19. The Roman-Doric order, Fig. 5, is similar both to the Greek-Doric and the Tuscan orders, but as a whole it is so modified that it would hardly be recognized as a descendant of the Grecian design. The stylobate is here replaced by a pedestal, and the shaft stands on a moulded base, which never existed in the Greek Doric. The column, Fig. 5, shows more ornamen-

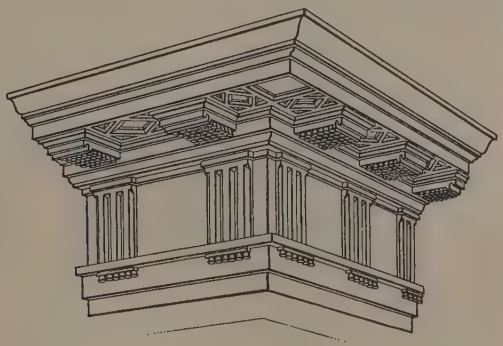


FIG. 6

tation than that on the drawing plate, in particular on the abacus and the echinus, the ornament being of the egg-and-dart order. In Fig. 6 is shown an enlarged view of the entablature. The flutes of the shaft are somewhat similar to those of the Greek order, but are composed of circular instead of elliptic arcs. The capital is decidedly different, and though the frieze still

Fig. 7 (a)

possesses the triglyphs and metopes, these details are differently proportioned and less regularly spaced than in the Greek order. The mutules are level on their under sides, and the crowning member of the corona is a cyma recta instead of an echinus.

20. Commence the plate by constructing a scale of modules $\frac{5}{16}''$ above the lower border line. The length of a module on the scale is here made equal to $1\frac{1}{8}''$. Draw *a b*, the centre line of Fig. **1**, at a distance of 4″ from the left-hand border line, and the base line *c d* $\frac{1}{2}''$ above the lower border line. Measure off on *a b* the divisions of the order, and draw horizontal lines defining these divisions. The letters *A*, *B*, etc., indicate the same parts on this plate as on the plate *Tuscan Order*.

Profile the mouldings of the pedestal, column, and entablature according to the measurements given, and draw the triglyphs and mutules in the entablature. Complete Fig. **1**, omitting for the present the fluting of the shaft. Now draw Figs. **3** and **4**, which are plans of the under side of the capital and upper side of the base, respectively. Draw the centre line *e f* $2\frac{7}{8}''$ from the right-hand border line. Set off on *e f* the centres of these views at distances of $7\frac{5}{16}''$ and $2\frac{7}{8}''$, respectively, above the lower border line. Draw the circular plan of the mouldings of the base and capital and the circular plan of the shaft. Draw the rectangular outlines of the mouldings on the abacus

in Fig. **3**, and of the plinth and pedestal in Fig. **4**. Divide the circumferences of the circles defining the plan of the shaft in Figs. **3** and **4** into 20 equal parts, and with the chord length of one of these parts as a radius, describe the arcs defining the flutes. The arrises between the flutes are now projected to the horizontal diameter of each plan in the manner previously described and by means of a paper strip their positions transferred to Fig. **1**.

21. Draw Fig. **2**, which is a plan of the under side of the cornice, placing the centre line $g\ h\ 3\frac{15}{16}''$ from the right-hand border line, and draw $i\ k\ 4\frac{9}{16}''$ below the upper border line. Draw the mouldings and the plans of the mutules from the dimensions given in Fig. **1**, and carefully outline the panels between the mutules. Some parts in this view will be better understood by studying corresponding parts in Fig. 6. The entasis of the column is not shown, but may be set off in the manner already described. In Fig. **1** the portions of the shaft that are shown are drawn with vertical sides. Complete Fig. **1**, drawing the flutes in the upper part of the column from measurements taken from Fig. **3**, and in the lower part of the column from measurements taken from Fig. **4**, as already explained.

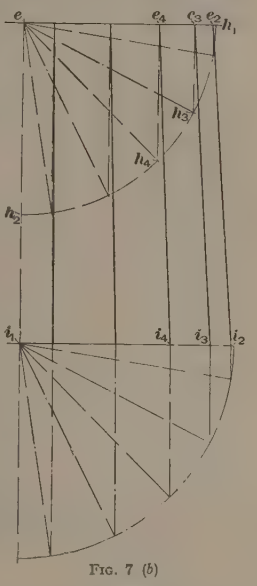


FIG. 7 (*b*)

22. While the shaft on the drawing plate does not show any entasis, by reason of the portions shown being too short, in reality the sides of the shaft will not be parallel to its axis, and the outer arrises will therefore also not be parallel to the latter. The construction of the entastic curve has already been shown on the plate entitled *Tuscan Order*, but how the inclination of the arrises between the flutes is to be determined in elevation has not been explained. This will be done by means of Fig. 7 (*a*), in which *e f* is the axis of the shaft, shown here in its entirety.

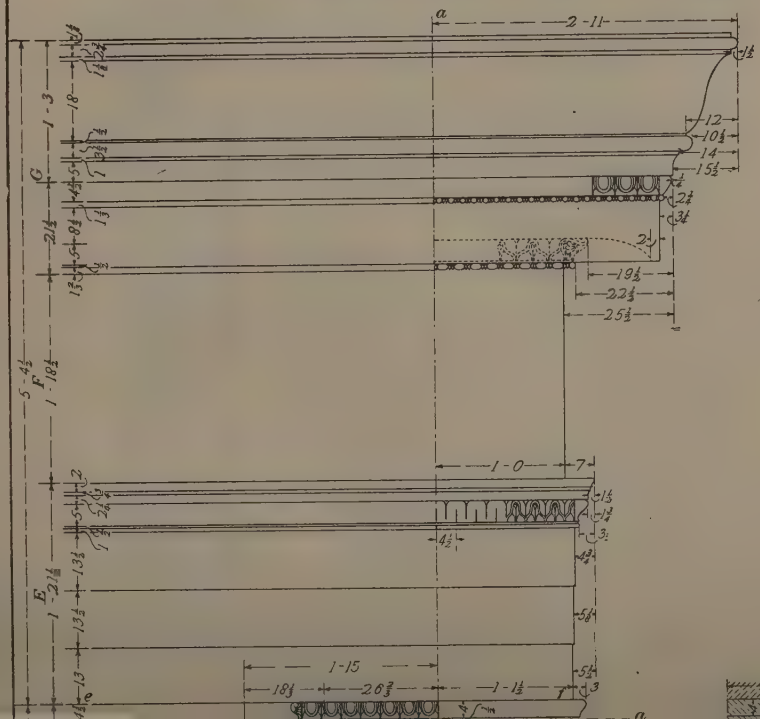
The upper and lower diameters are indicated by $h\,h_1$ and $g\,g_1$, respectively. Divide the shaft into 8 equal parts by the horizontal lines $i\,i_2$, $k\,k_2$, etc. With f as centre and $f\,g$ as radius describe the arc $g\,l$, and from h draw a vertical intersecting the arc at l. Divide the arc $g\,l$ also into 8 equal parts, and from point *1* draw a vertical intersecting $i\,i_2$ at i, from point *2* a vertical intersecting $k\,k_2$ at k, etc., in this manner finding all the points required for drawing the entastic curve. The points found are then connected by a curved line, as shown.

23. To determine the corresponding curvature of the arrises, it is necessary to find the positions of points on the arrises at several horizontal planes along the shaft. For this purpose the horizontal lines $h\,h_1$, $i\,i_2$ are used, each being supposed to represent a horizontal plane intersecting the shaft. Draw first with e as centre and $e\,h$ as radius a semicircle $h\,h_2\,h_1$; in the drawing only a quadrant is drawn, as the construction on both sides of the centre line $e\,f$ will be the same. Divide the quadrant into a number of parts corresponding to the number of arrises in a quadrant, in this case 10, for it has the two half flutes at each end. The next step in the construction will be shown in Fig. 7 (*b*). Each of the points of division is projected up to the line $e\,h_1$, thus the point h_3 to e_3, point h_4 to e_4, etc. The points thus found fix the positions of the arrises at this plane. It is to be noted that the point e_2 of the outermost arris does not coincide with the end h_1 of the diameter, because at this point there falls the recess of a flute. At the line $i_1\,i_2$ a similar construction is carried out, fixing points i_2, i_3, i_4, etc. This construction is repeated at all the horizontal lines drawn through the shaft, and at both sides of $e\,f$. All points similarly placed relative to the axis are then connected, as e_2, i_2; e_3, i_3; e_4, i_4, etc. The final result will then be as in Fig. 7 (*a*).

DRAWING PLATE, TITLE: GREEK IONIC ORDER

24. This plate shows the details of the Greek Ionic order, the stylobate being shown at *A*, the base, shaft, and capital of the column at *B*, *C*, and *D*, respectively; and the architrave,

GREEK IONIC ORDER



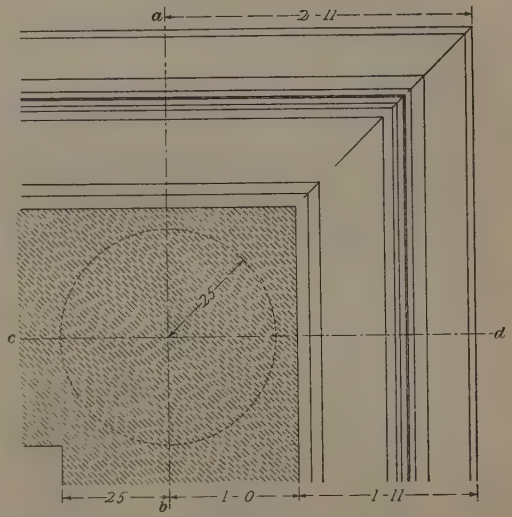
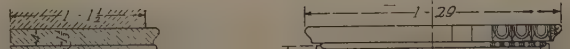


Fig. 7.



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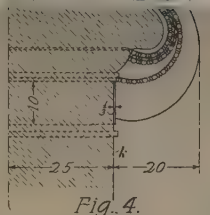


Fig. 4.

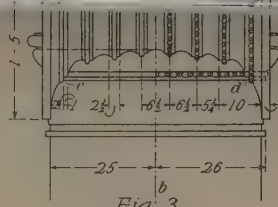


Fig. 3.

Fig. 2.

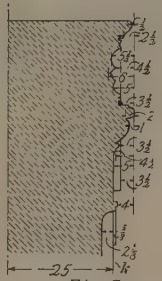


Fig. 5.

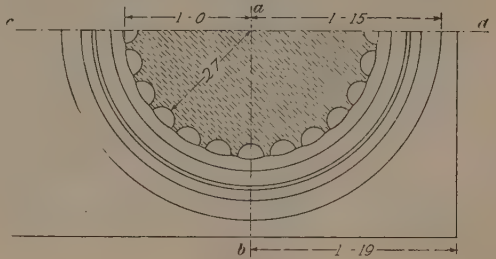


Fig. 6.

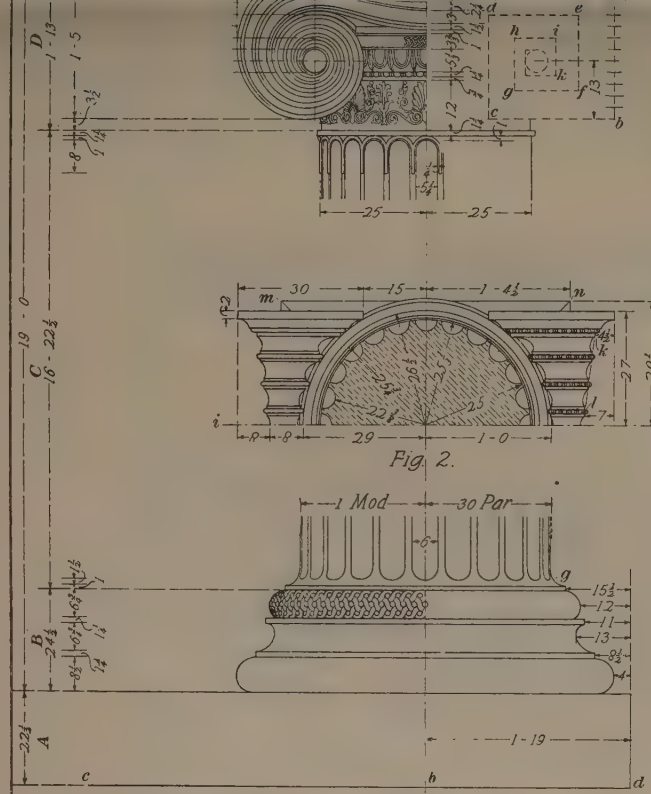


Fig. 1.

frieze, and cornice of the entablature at *E*, *F*, and *G*. A perspective view of the order is shown in Fig. 8.

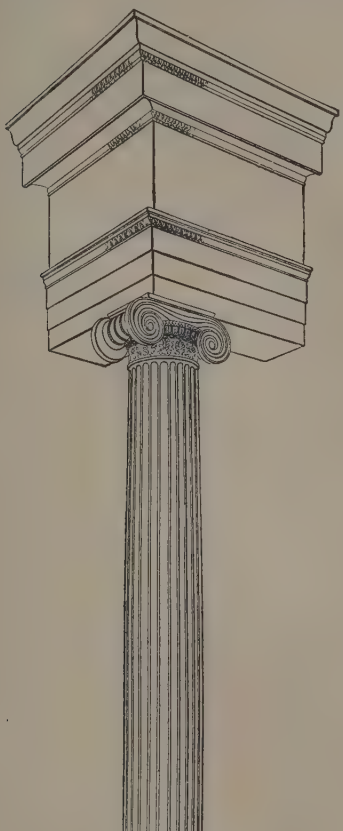


Fig. 8

Construct a scale of modules $\frac{5}{16}''$ above the lower border line, making a module equal to $1\frac{1}{4}''$. Now draw the centre line *a b* at a distance of $4\frac{1}{8}''$ from the left-hand border line and draw the lower side *c d* of the stylobate $\frac{3}{4}''$ above the lower border line. Draw *e f*, the bed line of the architrave, 8″ below the upper border line.

25. On the centre line *a b*, Fig. **1**, set off a number of points from the measurements given, fixing the positions of the horizontal lines of the base, capital, and entablature. Profile the mouldings of the base, omitting for the present the fluting of the shaft, though the sides of the *apophyge* may be shown. The term **apophyge** refers to the curved expansion of the shaft where it joins the base, as shown at *g*. Now proceed with the entablature, drawing the three fasciæ of the architrave and the mouldings crowning them. The latter should be profiled carefully according to the measurements given, but omitting, for the present, the ornament on the cyma reversa. It will be

observed that the frieze in this order is a plain band, devoid of any triglyphs or metopes, as found in the Doric, while the corona consists of a group of simple mouldings, elaborated with surface ornaments. Carefully draw these details, profiling their outline where they project at the return of the entablature, but omitting the ornament until the outlines of the other views on the plate are complete.

26. The capital *D* is the most complicated feature of the Ionic order. It consists essentially of a contracted echinus and a small torus, over which the *volutes*, or spirals, are turned, forming the distinctive characteristic of the order. A necking under the capital, which is usually decorated with carved ornaments, is separated from the shaft of the column by a narrow fillet, or bead moulding, called the **astragal.** Before drawing the capital, it is advisable to practise the construction of a volute on a separate sheet of paper until one becomes familiar with the principle that forms the basis of its design.

27. The volute in a variety of forms pervades all styles of ornament. The example shown on the plate is purely Greek in its proportions, and the ratio of its height to its width is governed by definite geometrical rules for each convolution or turn. In drawing the Grecian volute, Fig. 9, the construction lines *a b*, *b c*, and *c d* should be set off in the proportion of $13 : 11 : 9$, or, if more convenient, of $6\frac{1}{2} : 5\frac{1}{2} : 4\frac{1}{2}$; that is, if *a b* is $6\frac{1}{2}''$ long, then *b c* and *c d* must be $5\frac{1}{2}''$ and $4\frac{1}{2}''$, respectively. The length of *d e* can be found by means of *c d* and *e f*, as *e f* is always $\frac{1}{2}$ (*a b*) and *d e* is $\frac{1}{2}$ (*c d* + *e f*). The length of the succeeding lines is easily found, as each line is always one-half the length of the adjacent parallel line in the next larger convolution. For instance, *f g* is $\frac{1}{2}$ (*b c*), and *g h* is $\frac{1}{2}$ (*c d*), and so on. In this manner the convolutions can be decreased to any desired size, or, if necessary, they may be enlarged by drawing a line to the left from *a* of a length equal to twice *d e*, and so on round the volute.

28. The angles at *a*, *b*, *c*, and *d* are now bisected by lines inclined at 45° to the lines. Thus, *a x* is first drawn, then *b x* intersecting

a x at *x*; next *c y* intersecting *b x* at *y*, and finally *d w* intersecting *c y* at *w*. If *a x* is produced so as to intersect *d w* at *z*, the rectangle *x y w z* is formed. The sides of this rectangle are then bisected and the points thus found form the centres of the quadrants that form the volute. For instance, with *o* as a centre and with a radius equal to *o 1*, the curve *1–2* is described. Then, with *p* as a centre and with a radius *p 2*, the curve *2–3* is made; the curve *3–4* is described from *r* with a radius *r 3*, and the

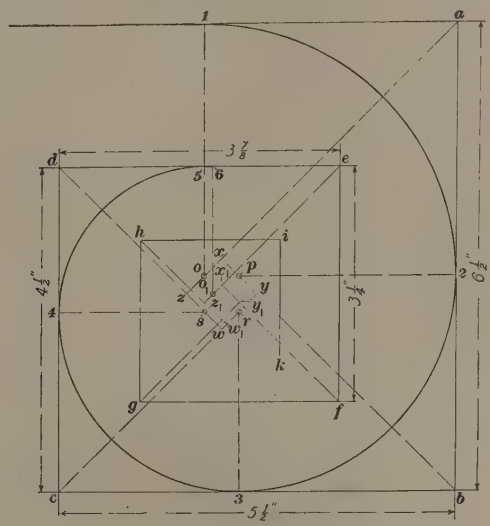


Fig. 9

curve *4–5* with *s* as a centre. In order that the beginning and end of each quadrant may be sharply defined, it is necessary to draw a number of radii at right angles to the construction lines, such as *o 1*, *p 2*, *r 3*, etc. The rectangle *x y w z* will serve only for describing the first four quadrants. For the purpose of continuing the volute, it is necessary to draw a new set of diagonal lines from the angles at *e*, *f*, *g*, and *h*, and to form a new and smaller square in the centre. Bisecting its sides, the centres are fixed for the next four quadrants. In this manner a new

rectangle must be constructed for each series of four quadrants. The second rectangle is shown at $x_1\ y_1\ w_1\ z_1$, with the first radius $o_1\ 6$. It will be found that the beginning of each series of quadrants will be at a point a short distance to the right of the end of the preceding one, in this case at the distance *5–6*. The end of the last quadrant should therefore be extended so as to reach the beginning of the succeeding quadrant. For instance, it will be found that the succeeding quadrant begins at *6*, the quadrant *4–5* should therefore be extended to the point *6*.

29. After the construction of Fig. 9 is thoroughly understood, the design of the volute on the drawing plate may begin. In order that its construction may be made clearer, an enlarged view of the volute is shown in Fig. 10 (*a*). The lines *a b*, *b c*, and *c d* are first set off in the proportion of 13 : 11 : 9. The position of these lines in Fig. 1 is indicated by dotted lines at the right-hand half of the capital. The distance between *a b* and the centre line is 1 m. 15 p. and the length of *a b* is 1 m. 5 p. Having drawn this line in its correct position, it is divided into 13 equal parts, which parts serve as a basis for the construction of the volute. It is evident that the setting out of the rectangular skeleton of the volute, even of the smallest parts, must be done with the greatest accuracy, otherwise the positions of the various centres will be inaccurate. The result of this is that the quadrants will not join properly.

30. By dividing *a b*, Fig. 10 (*a*), into 13 equal parts the other lines may be drawn to the lengths indicated on the dimension lines. The construction is easily followed up to the point *m*. From this point the horizontal *m t* is drawn; a square is then constructed in the angle *l m t* with a side *m* m_1 equal to one of the parts marked off on *a b*. In this square the point m_2 will be the required centre of the eye of the volute. Describe this eye with a radius equal to $m_2\ m_1$. Diagonals are now drawn from the points *a*, *b*, *c*, and *d* in the manner already described, the diagonals forming a square *w x y z*. Diagonals from *e*, *f*, *g*, *h* form the square $w_1\ x_1\ y_1\ z_1$, shown on a larger scale in Fig. 10 (*b*), and diagonals from the remaining points *i*, *k*, *l*, *m* form the square $w_2\ x_2\ y_2\ z_2$.

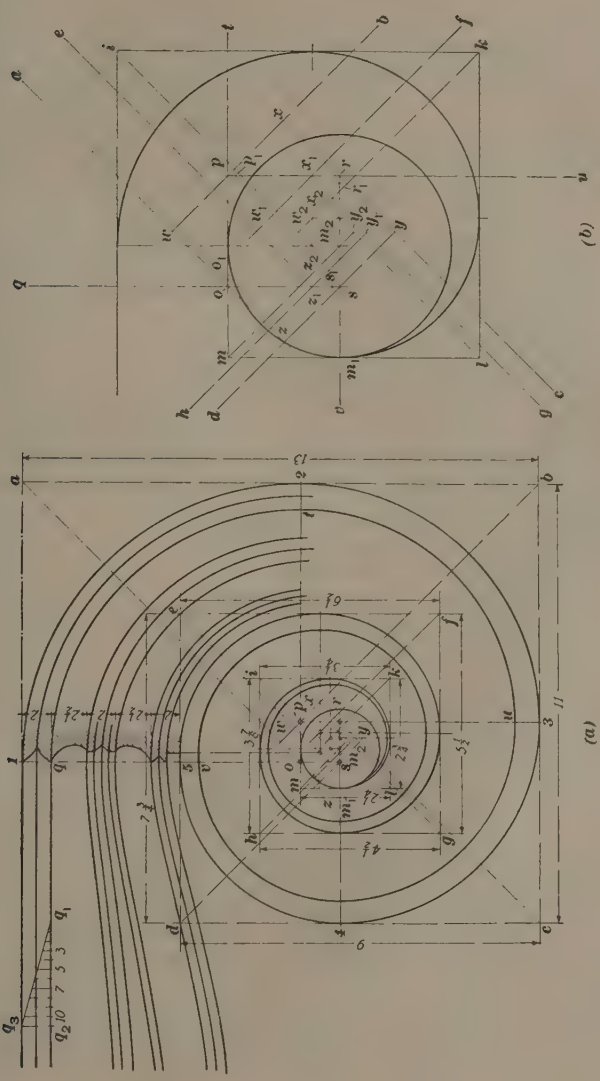


Fig. 10

The sides in the square *w x y z* are now bisected at *o*, *p*, *r*, *s* which points are the centres for the quadrants in the first convolution of the volute. Draw the radii *o 1*, *p 2*, *r 3*, and *s 4* and describe the four quadrants in the manner described in Art. **28.** The sides in the other rectangles are also bisected, radii drawn, and the quadrants described in a similar manner, the last quadrant being tangential to the eye at m_1.

31. The outline of the volute would now be complete if the convolutions consisted only of a single sharp edge. In reality, they are made up of a series of mouldings, termed **bands,** which decrease in width as they approach the eye. It is therefore necessary to find a convenient method by which they may be drawn. For this purpose it is first necessary to set off the width of the outer band, which, as seen from the drawing plate, is 2 p. wide. This dimension is set off from point *1*, thus fixing point *q*. The width *q 1* is now to be divided into 11 equal parts by any convenient means; for instance, as shown at $q_1\ q_2$, Fig. 10 (*a*), where 11 units of a suitable size are set off. By drawing the vertical $q_2\ q_3$, the oblique line $q_1\ q_3$, and then ordinates through the points of division on $q_1\ q_2$, it is seen that these ordinates will decrease in length by one-eleventh of $q_2\ q_3$, considered in the direction from q_2 to q_1. Thus, the first ordinate to the right of q_2 is 10 parts long, the second 9, and so on.

32. The width of the band at *2*, Fig. 10 (*a*), will be 10 of these parts, thus fixing the position of point *t*; at *3* the width will be 9 parts, fixing point *u*, and so on all the way round until the inner edge of this band becomes tangent to the eye. To draw the band, place one leg of the compass at *o* and set the pencil point for the radius *o q*, then with the needle point of the compass at *t* describe a short arc on *t o* near *o*. The point of intersection o_1, Fig. 10 (*b*), will be the centre of the quadrant *q t*. View (*b*) is an enlarged drawing of the central part of view (*a*), being inserted for the purpose of showing clearly the position of the centres for describing the bands. The position of the centre o_1 and the following centres are found more accurately by means of a pair of dividers, instead of the compass, the centre being pricked with one point instead of drawing the

intersecting arc with the pencil point. Describe the quadrant $q\ t$ from the centre o_1, then, with the dividers set to the length $t\ p$, place one of the divider points at u and with the other point prick off the point p_1, as shown in view (*b*). Then, with p_1 as a centre and $p\ t$ as radius, describe the quadrant $t\ u$. The other centres r_1, s_1 for this convolution are found in the same manner, and by their means the band is described up to point v. Now the second square $w_1\ x_1\ y_1\ z_1$ is used in a similar manner for describing the second convolution. Finally, the inner quadrant is used for the remaining part of the volute.

33. It is seen from the drawing plate that there are two other bands that converge toward the central eye. A profile of these two and the first band is shown at q in Fig. 10 (*a*). The figures indicating the proportions of the bands represent parts on the module scale, drawn on the plate, and it is seen that the sum of the dimensions is equal to 4 of the parts marked off on the line $a\ b$. The second and the third band are drawn in the same manner as the first, but a new set of squares must be constructed with other centres. It is not necessary to draw any more than a small portion of these volutes, as on the drawing plate. To complete them would be a difficult matter, because the small scale to which the drawing is made will not allow the centres to be placed correctly. Having completed this volute proceed to draw the volute on the left-hand side, the only difference being the reversed direction in which the volute turns.

34. Where these bands dip down at the centre of the capital, a number of points should be set off according to the scale of modules, and the curves first sketched freehand and afterwards strengthened with the irregular curve. The egg-and-dart ornament on the echinus and the guilloche on the torus may now be drawn in between the volutes, and the egg-and-dart on the echinus and water-leaf ornament on the cymas of the entablature. The cyma reversa, shown in *dotted lines* under the corona of the cornice, is so drawn because it is *undercut*, or recessed, behind the lower face of the corona, and is therefore not seen on the elevation of the order, though it appears in the perspective, Fig. 8, as the view of the cornice is there taken from below. Now proceed

with Fig. 2, which is a half-plan of the shaft, looking upwards. Draw $i\,j$ at right angles to $a\,b$ and $4\frac{3}{8}''$ above the lower border line. With a centre on the point of intersection of $i\,j$ and $a\,b$, and with a radius of 25 p., draw a semicircle, as shown. Divide the circumference of this semicircle into 12 equal parts, and on each of these points of division as a centre, and with a radius of $2\frac{5}{8}$ p., describe semicircles, which will be plans of the flutes, while the spaces between these semicircles, where they intersect the circumference of the shaft, will be the fillets between the flutes. Now project the lines of these flutes to the elevation of the upper part of the shaft, and draw their semicircular finish against the fillet under the shaft neck.

35. When there are fillets between the flutes, as in this order, the entastic curve of the fillets is constructed in the same manner as that of the arrises shown in Fig. 7. The difference is that, instead of only one line between each flute projected from the plan, there are two lines, as shown in Fig. 11. Here, for instance, are two points a, b on the upper quadrant projected to the horizontal $m\,n$ giving points a_1, b_1 on the curve. The points c, d on the lower quadrant are projected to the second plane $o\,p$, giving points c_1, d_1. Lines $a_1\,c_1$ and $b_1\,d_1$ define the upper end of this fillet. Otherwise the construction is a repetition of that shown in Fig. 7.

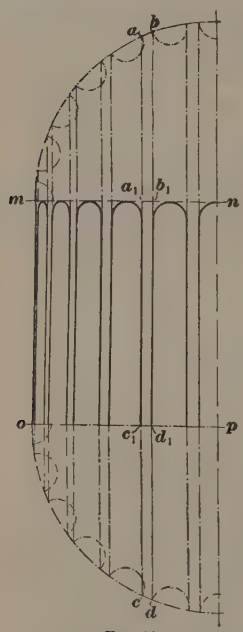


Fig. 11

36. To draw the flutes on the portion of the shaft immediately over the base, it will be necessary first to draw Fig. **6**, which is a half-plan of the shaft and base. Draw the line $c\,d$ $2\frac{3}{4}''$ above, and parallel to, the lower border line, and at right angles to $c\,d$ draw $a\,b$ $2\frac{3}{4}''$ from the right-hand border line. On the intersection of $a\,b$ and $c\,d$ as a centre, and with a radius of 1 m., draw the semicircular outline of the shaft;

divide the circumference of this semicircle into 12 equal parts, and with the points of these divisions as centres, and a radius of 3 p., draw the semicircular flutes and the fillets between them. Then draw the plan of the mouldings according to the measurements given in Fig. **1**, and the plan of the stylobate, which extends 4 p. beyond the lower torus of the base. Project the lines of the flutes and fillets to *c d*, and transfer their position to the lower portion of the shaft in Fig. **1**. Now complete the flutes and fillets in Fig. **1**, drawing their finish on the apophyge of the shaft, partly with the bow-pencil and partly freehand, as the case may require. As this outward curving part of the flutes will be visible in the plan, Fig. **6**, they must be indicated there by curves, as shown. An arc described with a radius of 10 p. is sufficiently correct for showing the plan of each of these curves.

37. Return to Fig. **2**, and draw the under side of the capital as shown. The portions of the volutes seen in the elevation are here observed to be only 2 p. in thickness, while the material behind the volute is hollowed out toward the shaft, and is ornamented with rows of bead moulding and fillets. This portion of the capital is called the *bolster*, and its appearance in section, on the line *i j*, may be seen in Fig. **4**, while a section through the capital between the volutes on the line *a b* is shown in Fig. **5**. To show the outline of the bolster in Fig. **2**, draw the line *k l*. The position of its upper end is seen from Fig. **3** to be 6 p. from the face of the outside volute, while the point *l* is 4 p. from *i j*. The line *k l* will give the taper of the bolster toward the centre line. The width and positions of the bead mouldings on the bolster may be obtained from Fig. **3**. Some of the smaller dimensions may have to be scaled by means of the scale of modules. The abacus is visible at *m n* in Fig. **2**, and the egg-and-dart moulding, seen in Fig. **1**, should be shown in plan, but this moulding has been purposely omitted.

38. Now draw Fig. **3**, which is a side elevation of the capital, showing the bolster. Draw the centre line *a b* at a distance of 2″ from, and parallel to, the right-hand border line. Project from Fig. **1** the horizontal lines of the abacus and the positions of the small torus, echinus, and fillet of the capital, which show

on the front elevation between the volutes. Project also the lines defining the depth of the volutes and the fillet immediately under the bead moulding. From this fillet line *c d* set off the distances between it and the bead mouldings on the bolster, as found by scaling Fig. **3.** Draw these bead mouldings and complete the figure in the manner shown.

Draw Figs. **4** and **5,** their centre lines being 6″ and $4\frac{7}{8}$″, respectively, from the right-hand border line. Let the top of Fig. **5** be $5\frac{7}{8}$″ above the lower border line. The lines defining the depths of the members on Fig. **4** should be projected from Fig. **1,** and the projection of these members from the centre of the column may be obtained from Fig. **2.** The face line of the shaft is shown in Fig. **4,** and in Fig. **5** at *k*. The heights of the mouldings on this line may be scaled from Fig. **1** or transferred by means of a strip of paper. The projection of the abacus, torus, and echinus may be obtained from Fig. **3,** but the other details should be scaled from the figure itself.

39. Now draw Fig. **7,** which is a plan of a section taken through the frieze, looking up. Draw the centre line *a b* at a distance of $3\frac{1}{16}$″ from the right-hand border line, and at right angles to *a b* draw *c d* $4\frac{1}{2}$″ from the upper border line. With the point of intersection of these lines as a centre, and with a radius of 25 p., draw a circle, which will be the plan of the top of the shaft of the column ; then measure off on *a b* 1 m. above *c d*, and measure off on *c d* 1 m. to the right of *a b* ; through the points so fixed draw a horizontal and a vertical line to define the projection of the frieze. Then, from the frieze line measure off the projections of the various members of the cornice, and draw lines defining these members. Draw the mitre lines where the cornice members intersect at the angle, and complete the figure.

Proceed to draw the ornamentation of the mouldings where such are indicated in the figures, section-line the parts shown in section, and complete the plate, carefully inserting all the dimensions, but omitting all the reference letters, except those shown in capitals, which refer to the main subdivisions of the order.

IONIC ORDER

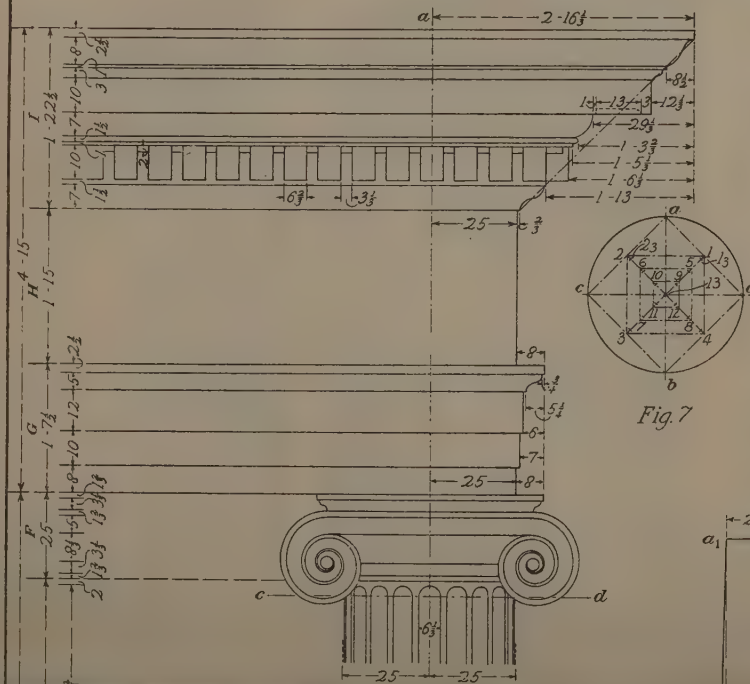


Fig. 7

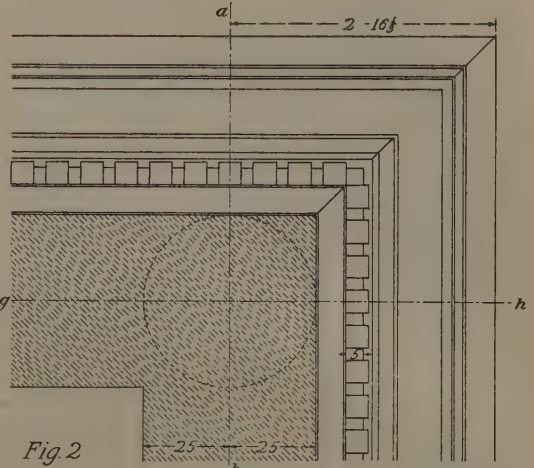
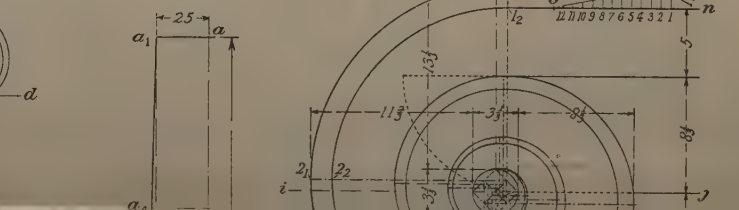


Fig. 2



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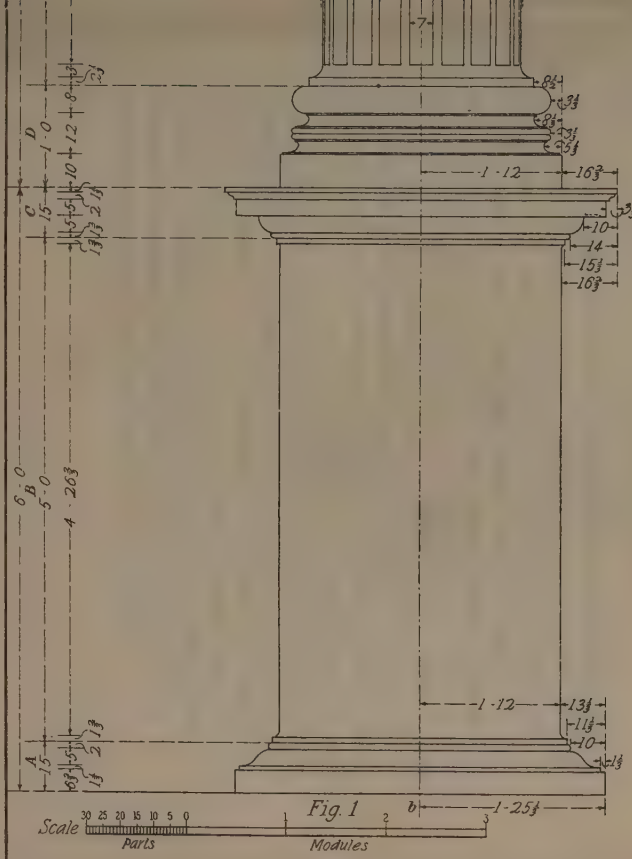


Fig. 1

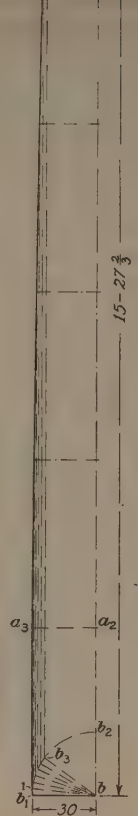


Fig. 5

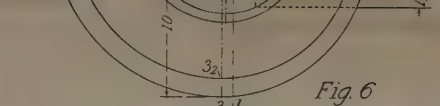


Fig. 6

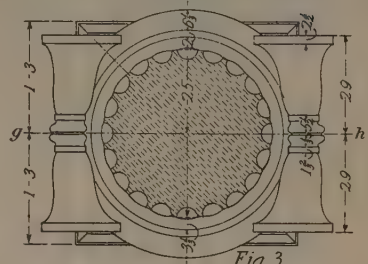


Fig. 3

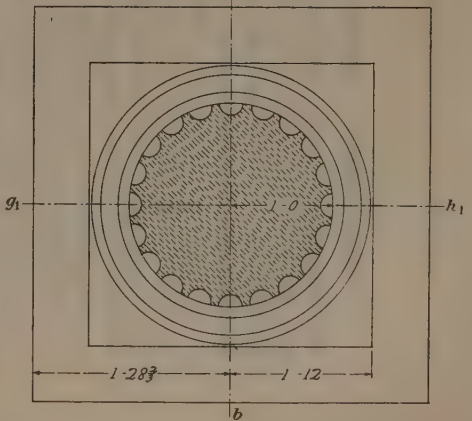


Fig. 4

DRAWING PLATE, TITLE: IONIC ORDER

40. The Roman-Ionic order differs from the Grecian order principally in the formation of the volutes of its capital, and the addition of the pedestal, as may be seen by comparing Fig. 12 of the text, which is a perspective of the Roman-Ionic order, with Fig. 8, the perspective view of the Greek Ionic.

Construct a scale 4 m. in length, $\frac{5}{16}''$ above the lower border line; then commence Fig. **1** by drawing the centre line *a b* $4\frac{1}{8}''$ from, and parallel to, the left-hand border line. Set off on *a b* the horizontal divisions of the order, and draw the lines defining these divisions. Draw the shaft, except the flutes and the volutes of the capital, by means of Fig. **1** and Fig. 13.

Now draw Fig. **6,** which is an elevation of the volute of the capital, 4 times the size of this detail in Fig. **1,** that is, 1 p. = 4 p. on the scale. Draw *k l* $2\frac{5}{8}''$ from, and parallel to, the right-hand border line, and the centre line *i j* $7\frac{7}{8}''$ below the upper border line. From the intersection of these lines, which is the centre of the eye, set off on *k l* 15 p. toward *k* and draw the horizontal line 1_1 *m*; describe the eye with a radius of $1\frac{2}{3}$ p.

41. The method of drawing the curves of this volute being essentially different from that practised by the Greeks, it will be necessary to leave Fig. **6** for the present and give attention to Fig. **7,** which shows the eye of the volute, drawn $3\frac{1}{2}$ times the scale of Fig. **6.** Draw *a b*, Fig. **7,** $6\frac{7}{8}''$ from, and parallel to, the right-hand border line, and draw *c d* at right angles to *a b* and 4″ below the upper border line. Now, with a radius of $\frac{3}{4}''$, and a centre *13* at the intersection of *a b* and *c d*, draw a circle whose diameter will be $3\frac{1}{2}$ times that of Fig. **6**; then draw the lines *a c*, *a d*, *b c*, and *b d*. Bisect *a c* and *a d* in points *2* and *1*, respectively, and draw lines *1–3* and *2–4* parallel to *a c* and *a d*, respectively. Now from their points of intersection with *a c b d* draw the square *1–2–3–4*. Divide each of the lines *2–13* and *13–4* into 3 equal parts and through the points of division draw horizontal and vertical lines between the radial lines, thus defining the smaller squares *5–6–7–8* and *9–10–11–12*. The centres for drawing the arcs of the volute are at *1*, *2*, *3*, *4*, etc.

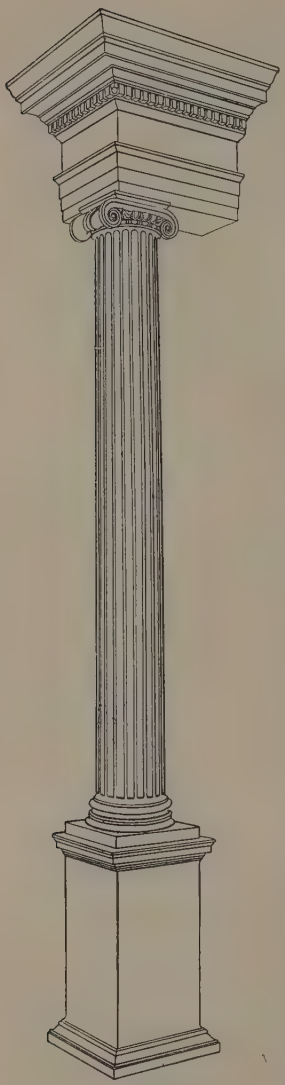


FIG. 12

42. Locate the centres in the eye of Fig. **6** by the method followed in Fig. **7**, and proceed to draw the arcs. From centre *1*, Fig. **7**, with a radius equal to $1–1_1$, Fig. **6**, draw the arc $1_1–2_1$; from centre *2*, with a radius equal to $2–2_1$, draw the arc $2_1–3_1$, and continue thus until the outer line of the volute is complete. Before drawing the inner line of the fillet of the volute, which gradually diminishes to a point where it unites tangentially with the eye, it will be necessary to define its width at the end of each quadrant; draw the fillet line $1_2 n$ at a distance of $1\frac{2}{3}$ p. below the upper line $1_1 m$, and on it mark any point, as at *o*. Set off from *o* 12 equal spaces of any convenient size, as at *12, 11, 10*, etc., and through point *1* draw a vertical line $1–o_2$. Join *o* and o_2 by an oblique line, as shown, and from the points *1, 2, 3*, etc., draw vertical lines intersecting the oblique line. These vertical lines are used for defining the varying width of the volute in the same manner as on the preceding plate. The length of the line $o_2 1$ being equal to $1_1–1_2$, it need not be transferred, but the vertical at *2* is set off with the dividers at 2_1, thus fixing the point 2_2. The other ordinates are set off in the same manner along the radial lines of the volute and in consecutive order until the point is reached where the volute is tangent to the eye.

43. To draw the quadrant 1_2–2_2 proceed as follows: Set the dividers to the radius 1_2–1, the centre 1 being shown in Fig. **7** and is the centre used in describing the quadrant 1_1–2_1. Then, with one point of the dividers at 2_2, prick with the other point a hole at 1_3 on the line 1–3, as shown. The quadrant 1_2–2_2 is now described from the point 1_3 as a centre. Next find the position of the centre for the quadrant 2_2–3_2 by setting off from point 3_2 a distance 2_2–2, thus fixing the position of the centre 2_3, shown in Fig. **7**. Now from 2_3 as a centre and with a radius 2_2–2 describe the quadrant 2_2–3_2. The remaining part of this volute is drawn in a similar manner. Now draw the volutes and finish the capital in Fig. **1**.

44. Proceeding with Fig. **3**, which is a plan looking up at the upper part of the column, draw the centre line $a\ b$ $2\frac{1}{16}''$ from the right-hand border line, and draw $g\ h$ $6\frac{1}{8}''$ above the lower border line. Describe a circle defining the circumference of the upper part of the shaft, and divide this circle into 20 equal parts. Then, with the points of division as centres, draw the fillets and flutes of the shaft, each fillet being one-third the width of a flute. Draw the mouldings of the neck and of the abacus; also the bolsters between volutes, the latter part freehand.

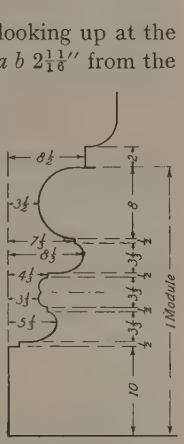


Fig. 13

Now draw Fig. **4**, the plan of the base and pedestal. Draw the centre line $g_1\ h_1$ $2\frac{1}{16}''$ above the lower border line, and with the point of intersection of $g_1\ h_1$ and $a\ b$ as a centre, and a radius of 1 m., draw the circular plan of the shaft. Divide the circumference of the shaft section into 20 equal parts, and draw the flutes and fillets, each fillet being one-third the width of a flute; then draw the mouldings of the base and the plan of the plinth and pedestal.

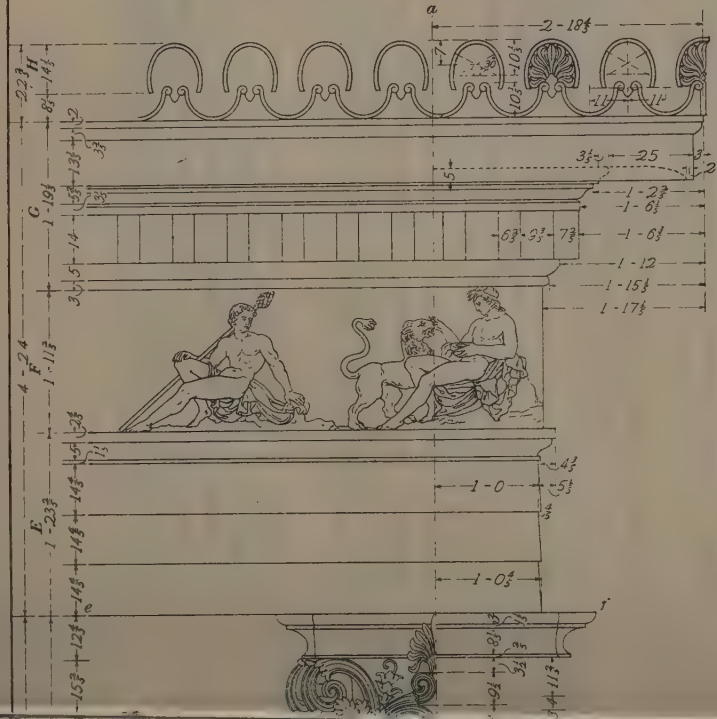
45. The profile of the entasis of the column may now be drawn, as in Fig. **5**. Draw the centre line $a\ b$ at a distance of $5\frac{1}{2}''$ from the right-hand border line, and draw the base line $b\ b_1$ in line with the lower line of the pedestal, Fig. **1**. Draw the top

line at a distance of 10 m. above $b\ b_1$. As the length of the shaft, exclusive of the apophyge at each end, is 15 m. $27\frac{2}{3}$ p., it is seen that it is drawn to a reduced scale, hence the radii at top and bottom must be reduced accordingly. These are drawn sufficiently accurate by making $a\ a_1$ and $b\ b_1$ 16 p. and 19 p., respectively, these dimensions corresponding to 25 p. and 30 p. as marked in Fig. **1** on the drawing plate. From b as a centre, Fig. **5**, and with a radius of 19 p. describe an arc $b_1\ b_2$. From a_1 draw a line $a_1\ b_3$ parallel to $a\ b$ intersecting the arc at b_3; divide the arc $b_1\ b_3$ into 6 equal parts, as shown. Divide the centre line $a\ b$ into a similar number of equal parts, and draw horizontal lines through the points of division. For the purpose of indicating the divisions on arc $b_1\ b_3$ more clearly, they have been connected with the centre b by radial lines. From point *1* on the arc draw a line parallel to $a_1\ b_3$; its intersection with the horizontal through a_2 will give point a_3 on the entasis. By finding the points of intersection of the other lines, taken in the same order, the entire profile of the entasis will be defined by points. These points may then be connected by a curved line.

46. Draw the line of the shaft below the neck of the capital in Fig. **1** parallel to $a_1\ a_4$ in Fig. **5**, which will give the taper of the shaft at that place. Make the taper of the shaft the same on the right side of the centre line $a\ b$ by measuring from the latter. Since the lower portion of the shaft is nearly cylindrical, the lines representing this part in Fig. **1** are drawn parallel to the centre line $a\ b$. In order to draw the fluting of the lower portion of the shaft, project the edges of the flutes in Fig. **4** down to the centre line $g_1\ h_1$ by lines parallel to the centre line $a\ b$. Transfer their position on line $g_1\ h_1$ by means of a strip of paper on which the points have been marked off, carefully indicating the position of the centre line $a\ b$.

47. To draw the fluting of the upper portion of the shaft, a different procedure will be necessary by reason of the taper of the shaft. Project first the flutes in Fig. **3** to the centre line $g\ h$ and transfer the points found to a horizontal line $c\ d$ passing through the curve centres at the ends of the flutes. This line is at a distance of $4\frac{1}{2}$ p. below the lower limiting line

GREEK CORINTHIAN ORDER



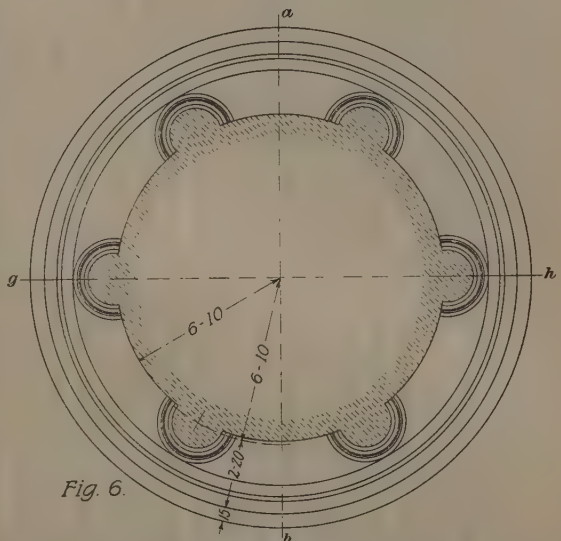
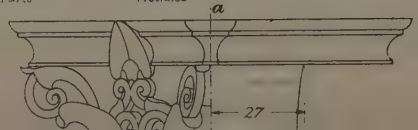


Fig. 6.

Scale 30 15 0 1 2 3 4 5 6 7 8 9 10
Parts Modules



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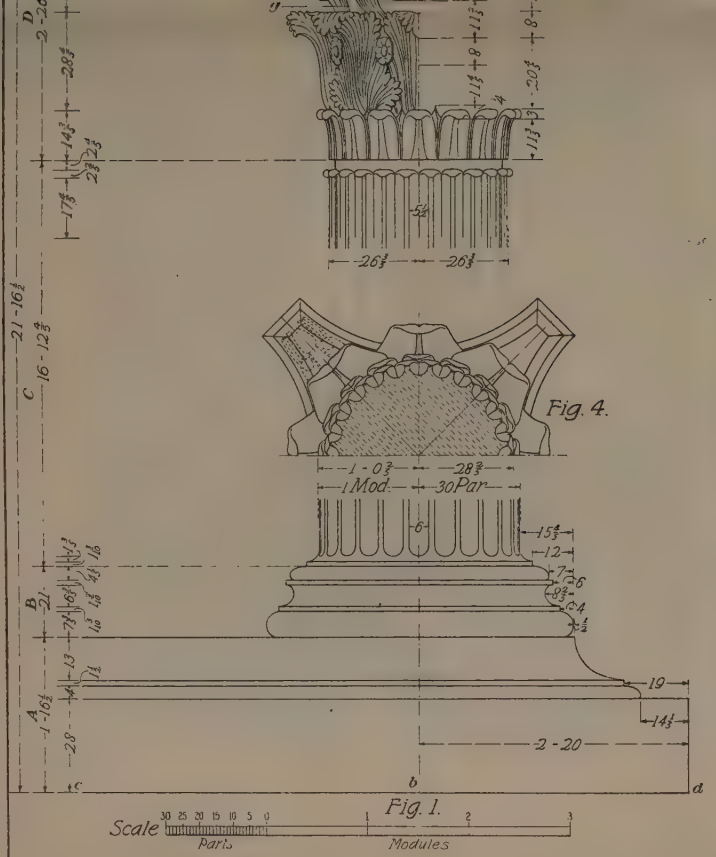


Fig. 1.

Fig. 4.

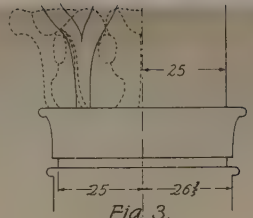


Fig. 3.

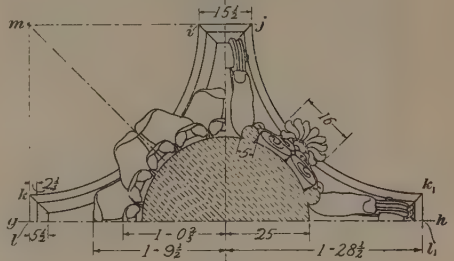


Fig. 2.

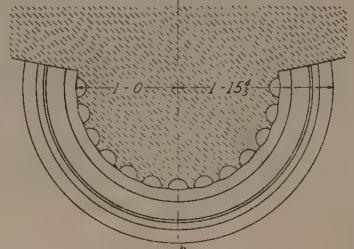


Fig. 5.

of the portion *F*. As the sides of the shaft taper, the sides of the flutes will also taper, but less and less as they approach the centre line. It will be sufficiently correct if the outer flutes are drawn parallel to the side of the shaft and the others made more nearly vertical as they approach the centre line.

Now draw Fig. **2**, the plan of the soffit of the cornice. Draw *a b* $3\frac{5}{16}''$ from the right-hand border line, and *g h* $3\frac{15}{16}''$ below the upper border line. The projection of the mouldings may now be obtained from Fig. **1** and the view completed in the manner shown. Complete the plate, putting in all dimensions, and insert the section lining where required. Insert dimensions, but omit the reference letters.

DRAWING PLATE, TITLE: GREEK CORINTHIAN ORDER

48. The details of the Greek Corinthian order shown on this plate are parts of the Choragic Monument of Lysicrates, 335 B.C., which is shown in Fig. 14 surmounted by the bronze tripod *b*, to receive which it was built. The columns *d* stand on a circular stylobate *c* and are arranged round the cylinder *e*. The columns in this structure are not free, but are **engaged**; that is, they are part of the cylinder *e* into which they are sunk for a distance of a little less than half their diameter. This is clearly seen from the plan, Fig. **6**, on the drawing plate. The cylinder *e* and the substructure *a*, Fig. 14, are not parts of the order. The shaft of each column is grooved by 24 flutes separated by fillets, as in the Ionic order, but the shaft is longer in proportion to its diameter. It also has a moulded base similar to the Ionic, but this spreads more in order to give an appearance of greater stability to the slender column. The capital *f* is also taller than that of any of the other orders, and is carved in representation of foliage arranged round a bell-shaped core. The entablature is similar to that part of the Ionic order, the architrave being in three faces and the frieze sculptured. A general type of a Corinthian column with the corresponding entablature is shown in Fig. 15.

49. On the plate the division *A* includes the two upper steps of the stylobate; *B*, *C*, and *D* show the base, shaft, and capital of the column, while *E*, *F*, and *G* are the architrave, frieze, and cornice of the entablature. Construct a scale of modules, as shown on the plate, at a distance of $\frac{5}{16}''$ above the lower border line; make 1 m. equal to 1″. Commence Fig. **1**, the elevation of the order, by drawing the centre line *a b* at a distance of $4\frac{1}{8}''$ from, and parallel to, the left-hand border line. Draw the lower side of the base *c d* $\frac{3}{4}''$ above the lower border line and the under side of the architrave *e f* 7″ below the upper border line. On the centre line *a b* set off a series of measurements fixing the principal divisions of the column and entablature, and draw the horizontal lines defining them. Profile the mouldings of the base according to the measurements given, and draw the side lines of the shaft, but omit for the present the

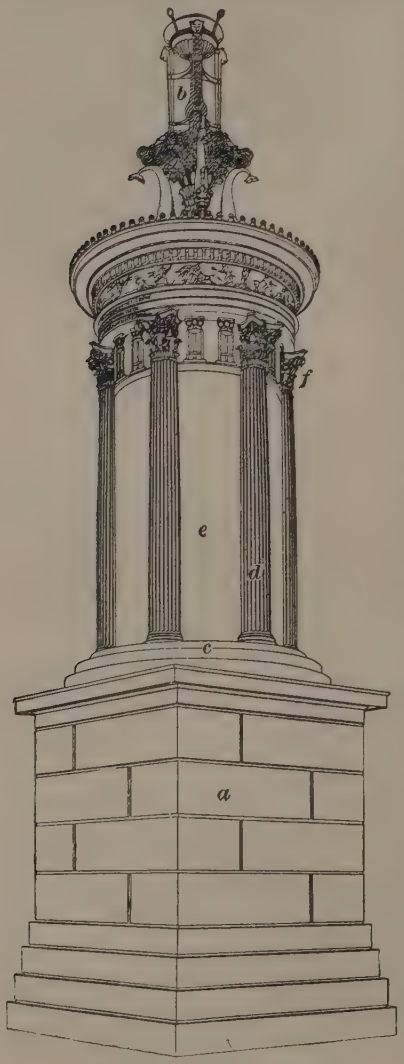


FIG. 14

fluting of the shaft. Draw the abacus of the capital and the three fasciæ of the architrave, observing that the fasciæ do not lie in perpendicular planes, but incline toward the interior, so that the outer edge of each is on the same perpendicular line as the one next above or below. Omit for the present the carving on the frieze, but draw the mouldings over the frieze and place the dentils in the cornice according to the measurements given. Over the dentil course is a cyma, and above this the corona; draw the echinus and fillet above the corona, and add the *antefixæ* and cresting which crown the entablature. By **antefixæ** are meant the upright ornaments above the eaves used for the purpose of hiding the joint between adjacent rows of tiles.

FIG. 15

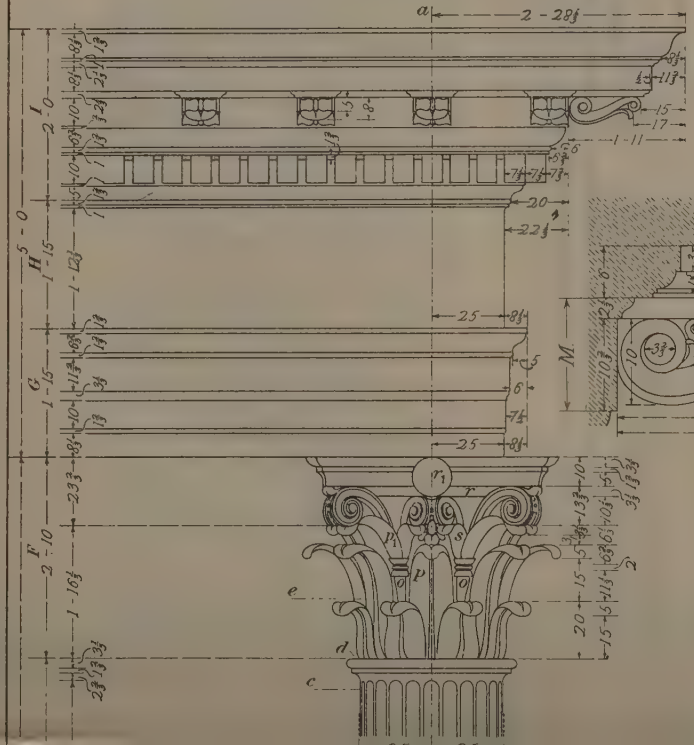
50. Now draw Fig. **2**, which is a half-plan of the capital, looking upwards, and with the capital turned through an angle of 45°. Draw the centre line *a b*, which is common to Figs. **2**, **3**, and **5**, at a distance of $2\frac{11}{16}''$ from, and parallel to, the right-hand border line, and draw *g h* 4″ above the lower border line. From the point of intersection of these lines, and with a radius of 25 p., draw the circular outline of the *bell* of the capital as it would

appear in section at the top of the first row of leaves. The body of the capital on which the foliage is arranged is called the **bell,** or core. With a radius of 1 m. $28\frac{1}{2}$ p., draw a circle limiting the projection of the angles of the abacus. From the intersection of this circle with the axial lines *a b* and *g h*, set off the width of the projecting angles, and draw *i j*, *k l*, and $k_1 l_1$ tangent to the circle at its intersections with the axial lines; then *i j* and *k l* will intersect at *m*. Now, with *m* as a centre, and a radius of 1 m. $20\frac{3}{4}$ p., describe an arc, which will be one of the sides of the abacus, between the angles. Draw this arc on the two sides, and then increase the radius and draw the arcs of the mouldings of the abacus. Place on the concave sides the block outline of the ornament on the abacus, which is shown in the *elevation*, Fig. **1**, to the left of the centre line *a b*. It will be observed that, while the abacus in the Doric order is simply a square slab, and in the Ionic order a slab with moulded edges, in the Corinthian order it is deeply hollowed and moulded on its sides, and its angles are cut off on straight lines at right angles to the axes.

It is noticed that Fig. **2** is not symmetrical with reference to the centre line *a b*. The part to the left of the latter is a plan taken through the neck of the column. In this view the scrolls near the abacus have been omitted so as not to make the drawing too involved. The part to the right of the centre line is a plan taken on a line at *g*, Fig. **1**.

51. To draw Fig. **3,** which is an elevation of the capital viewed from the same position as Fig. **2,** project the horizontal lines of the abacus from Fig. **1,** and its breadth across the angles from Fig. **2.** Draw in the leaves and ornament from the dimensions given in Figs. **1** and **2.** The foliated ornament on the Corinthian capital consists of a number of *caulis*, or husks, out of which the *caulicoli*, or twisted stems, spring, forming small spirals or volutes at the sides and angles of the abacus. Now proceed with Fig. **4,** which is a plan of the capital similar to Fig. **2,** but taken as it would appear from a section through the shaft of the column, and placed in the position that it bears to the elevation in Fig. **1.** Draw 11 complete and two half-semicircular

CORINTHIAN ORDER



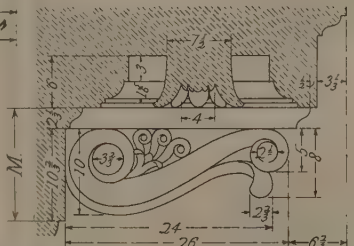


Fig. 7

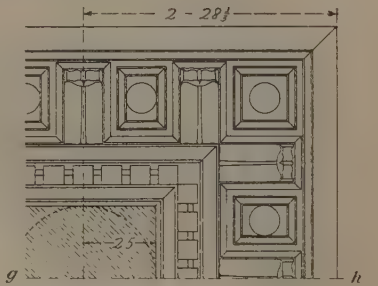


Fig. 9

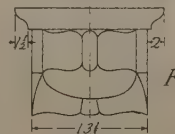


Fig. 8

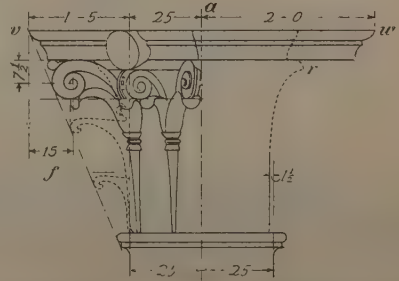


Fig. 3

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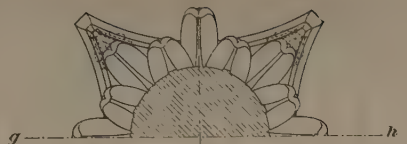


Fig. 6

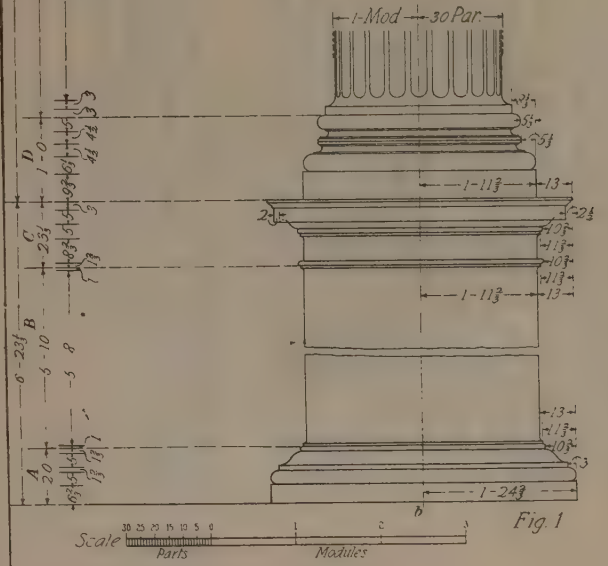


Fig. 1

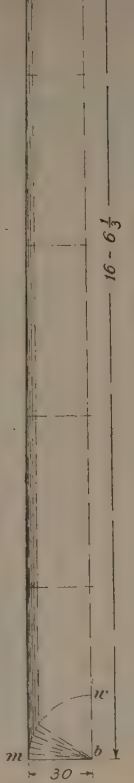


Fig. 5

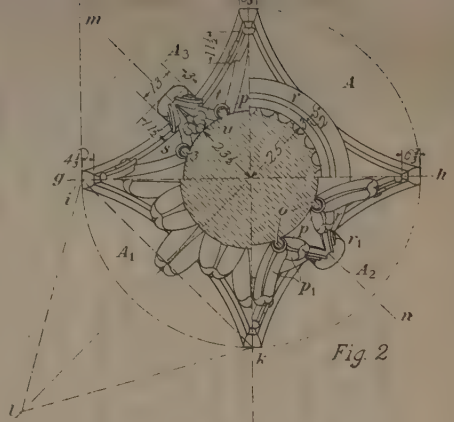


Fig. 2

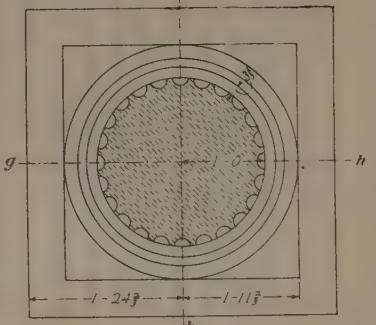


Fig. 4

flutes in this plan, leaving a fillet between each pair of flutes, equal to one-fourth the width of the flute, and project the lines of these flutes and fillets to Fig. **1**, as shown. It will be observed that the flutes and fillets terminate in leaf forms at their upper ends, and that the central vein of each leaf is the termination of the fillet; also, that between each pair of leaves another vein extends down into the flute itself. Draw these veins in the flutes shown in Fig. **4**, and also the projection of the leaves over the edges of the fillets.

52. Finish the foliage in the capital, Fig. **1**, setting out the design in a set of squares, if desired, and drawing the leaf-work freehand. Draw the plan of the base as shown in Fig. **5**, placing its centre point $2\frac{1}{4}''$ above the lower border line. With a radius of 1 m., draw the circular outline of the shaft, and divide it into 24 parts, each of which will include 1 flute and 1 fillet. Draw 12 of these flutes and fillets, and with a strip of paper transfer their projection to Fig. **1**; then draw the elevation of the flutes on the lower part of the column. Draw the circular outlines of the base mouldings in Fig. **5** from the measurements given in Fig. **1**; also draw a portion of the cylinder that forms the central part of the structure, the radius being 6 m. 10 p.

53. Now draw Fig. **6**, which is a plan of the monument that shows the three steps of the stylobate and the columns embedded in the cylindrical centre. Place the centre lines *a b* and *g h* at distances of $3\frac{3}{16}''$ and $3\frac{7}{8}''$, respectively, from the right-hand and the upper border line. This view is drawn to a different scale, the length of a module being taken as $\frac{1}{4}''$; a scale of modules based on this unit is therefore drawn below Fig. **6**. The carved ornament on the frieze in Fig. **1** may now be drawn, using a system of squares for the purpose of fixing the positions of the more important points. Also draw the antefixæ *H* over the cornice.

DRAWING PLATE, TITLE: CORINTHIAN ORDER

54. The Roman-Corinthian order, Fig. 16, differs from its Greek prototype principally in the elaboration of its entablature and the arrangement of the foliage of its capital.

Construct the scale of modules by drawing a line $\frac{5}{16}''$ above the lower border line, on which set off the modules, making 1 m. equal to $\frac{27}{32}''$. Commence Fig. **1** by drawing the centre line *a b* $4\frac{1}{8}''$ from, and parallel to, the left-hand border; and from a point $\frac{3}{4}''$ above the lower border set off on *a b* the measurements fixing the horizontal divisions of the order, and draw lines defining these divisions. Profile the mouldings of the pedestal, base, and entablature, according to the measurements on the plate, but omit the capital until the details of its foliage have been drawn.

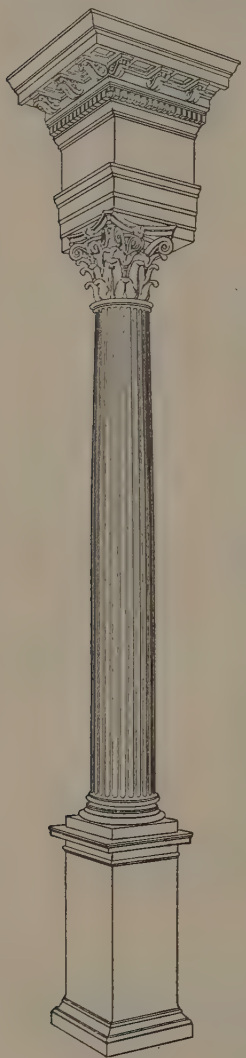


FIG. 16

55. Now draw Figs. **2** and **3**, the plan of the under side and the angular elevation of the capital. Draw the centre line *a b* $2\frac{1}{4}''$ from the right-hand border line, and draw *g h*, in Fig. **2**, $6\frac{7}{16}''$ above the lower border line. The point of intersection of these lines is the centre of the column. Fig. **2** combines four different plans taken on various levels of the capital. The plan shown in quadrant *A* is taken on the line at *c*, Fig. **1**. To draw this plan describe a quadrant with a radius of 25 p., defining the circumference of the shaft. The two next larger quadrants in this plan indicate the astragal of the shaft, and the largest quadrant represents the projecting lip *r* of the bell shown by dotted lines in Fig. **3**. With a radius of 2 m., draw a circle limiting the projection of the angles of the abacus. Draw *i k*, and with this line as a base construct the equilateral triangle *i k l*; mark half the width of

the angles of the abacus, or $3\frac{1}{3}$ p., on each side of the axial lines *a b* and *g h*, as shown. With *l* as a centre describe the arc defining the concave side of the abacus. Draw the other three sides of the abacus in the same manner, also the centre line *m n* to serve as a centre line for the ornaments on the abacus and the bell. Divide the circumference of the shaft contained in quadrant *A* into 6 equal parts, the points of division serving as centres for the flutes, which are constructed in the same manner as on the previous plate.

56. The quadrant A_1 is a plan taken at *d*, Fig. **1**, at the top of the astragal and shows the two lower rows of acanthus leaves that surround the bell. As seen from Figs. **1** and **6**, there are three rows of acanthus leaves. In the two lower rows there are eight leaves in each, those in the second row being placed between those in the first. They all spring from the astragal at the top of the shaft. These leaves must be drawn freehand, scaling the drawing plate for the necessary dimensions. The volutes at the points of the abacus have been omitted in this plan.

57. The quadrant A_2, Fig. **2**, is a plan taken on the line at *e*, Fig. **1**. At *o*, Fig. **2**, are sections through two of the eight *caulicoli*, or cabbage stalks, that are grouped round the bell. These stalks are also shown at *o* in Fig. **1**, where they are seen to terminate in a *button*, at *p*; above this is a *bud* p_1 which divides into two leaves. These leaves are also shown in the plan A_2, Fig. **2**. From each bud rise two volutes, one of which runs out to support the projecting corner of the abacus; the other does not rise higher than the lip *r* of the bell, Figs. **1** and **3**, and supports the *fleuron* r_1. The latter part is here shown as a circular block, but it is always given some ornamental form, one of which is shown in Fig. 16. Sixteen leaves of a third row of leaves curl forwards under these sixteen volutes. Two of these leaves are shown at *s* in Figs. **1** and **2**. In the quadrant A_2 they have been omitted, so as not to obstruct the view of the two volutes. The latter cannot be drawn before Fig. **3** has been completed.

58. The quadrant A_3, Fig. **2**, is a plan taken on the same line as that of quadrant A_2, but some of the lower parts have

been omitted for the purpose of showing the volutes and the third series of leaves at *s*. At *t* are shown two of the volutes that spring from the bud *p*, and at *s* are seen two of the leaves that belong to the third series of acanthus leaves. The common stem to these leaves is shown in section at *u*.

59. Now draw Fig. **3,** placing the line *v w*, the upper side of the abacus, $5\frac{1}{2}''$ below the upper border line. Draw the horizontal lines of the abacus, bell, and astragal according to the measurements given in Fig. **1.** Place the centre of the eye of the large volute $7\frac{1}{2}$ p. below the abacus and 15 p. inside the left-hand edge of the abacus; then draw the volute freehand. Points in the curves of the volute may now be projected to Fig. **2,** and the volute may then be drawn in place.

Complete Fig. **2,** drawing the plan of the caulicoli and volutes, and the moulding lines on the angles and concave sides. The right side of Fig. **3** is left plain, to show clearly the outline of the bell, but on the left side the foliage is shown in position, the centre lines of the stems being projected from Fig. **2.** The dotted outlines on the extreme left show the projection of the two tiers of leaves, which is limited by a line drawn from the edge of the abacus to the edge of the astragal.

60. A half-plan of the capital should now be drawn, as in Fig. **6,** letting the centre line *g h* be a continuation of the line *g h* in Fig. **2.** Draw the leaves in this view to correspond with those shown in quadrant A_1, Fig. **2.**

Now finish the capital in Fig. **1,** projecting the lines of the abacus from Fig. **3,** and profiling the mouldings at the angles of the abacus, by projecting lines from Fig. **6.** Draw in the leaves and caulicoli as shown, carefully drawing the curl at the tips of the leaves according to the measurements given.

Now draw Fig. **4,** the plan of the base and pedestal, placing *g h* $2\frac{1}{1}''$ above the lower border line. Draw the flutes of the shaft and mouldings of the base, as described for the previous plate, and project the lines of the flutes to a strip of paper and transfer them to Fig. **1**; then draw the flutes in the lower part of the shaft in Fig. **1** and proceed to Fig. **5.** The line *a b* is placed $5\frac{1}{2}''$ from the right-hand border line, and is 16 m. $6\frac{1}{3}$ p.

in length, but is drawn to a different scale from the other views, the module in this case being equal to $\frac{5}{8}''$. The line *a b* will therefore be approximately $10\frac{1}{8}''$ long, and the upper radius of the shaft about $\frac{1}{2}''$. The arc *m w* is divided as shown, and the entasis of the column is obtained according to the method explained on the previous plate. Draw the flutes on the upper part of the column in Fig. **1.**

61. Now draw Figs. **7** and **8,** which are elevations of the side and front of one of the **modillions,** or brackets, under the corona of the cornice drawn to 3 times the scale of Fig. **1.**

These modillions are a very much modified form of the Doric mutule, but are more elaborate than their prototype, combining in one design the scroll or volute of the Ionic capital and the rich foliation of the Corinthian. The extreme projection of the modillion is $28\frac{5}{6}$ p., and its depth is $12\frac{1}{3}$ p. The depth of the *modillion band*, which is the part of the cornice indicated by *M* in Fig. **7,** is 13 p., and the depth of the moulded table that forms the top of each modillion is $2\frac{1}{3}$ p. Deducting the latter dimension from the depth of the modillion band leaves the part *a b*, Fig. 17, which is an illustration showing the modillion to a larger scale, so as to show its construction in detail. Divide the line *a b* into 32 equal parts, these parts being used as a basis for constructing the modillion. Draw horizontal lines from the 5th, 10th, 12th, 15th, 20th, 25th, 28th, and 30th division points. The total depth of the volute is 30 parts. Set off from point *12* a horizontal distance of 15 parts, fixing the centre of the eye *o* of the large volute. The diameter *c d* of the eye is 11 parts long. With *o* as a centre and with a radius equal to 2 parts, describe the smaller circle, and in the latter inscribe the square, as shown. Bisect its sides, obtaining the points *1*, *2*, *3*, and *4*, which points are the centres for the quadrants 1–2_1, 2_1–3_1, 3_1–4_1, and 4_1–5_1. Bisect *o 1* at *5* and draw 5–5_1 ; point 5_1 will then be the end of the arc 4_1–5_1. From point *5* draw a horizontal 5–6_1 intersecting line *2*–*4* at *6*. Point *5* is the centre for the arc 5_1–6_1, and point *6* for the arc 6_1–*7*.

62. Draw a vertical through point *d*, Fig. 17, intersecting $a\,a_1$ at *e*, and set off from *e* a distance *e f* equal to 50 parts. A vertical

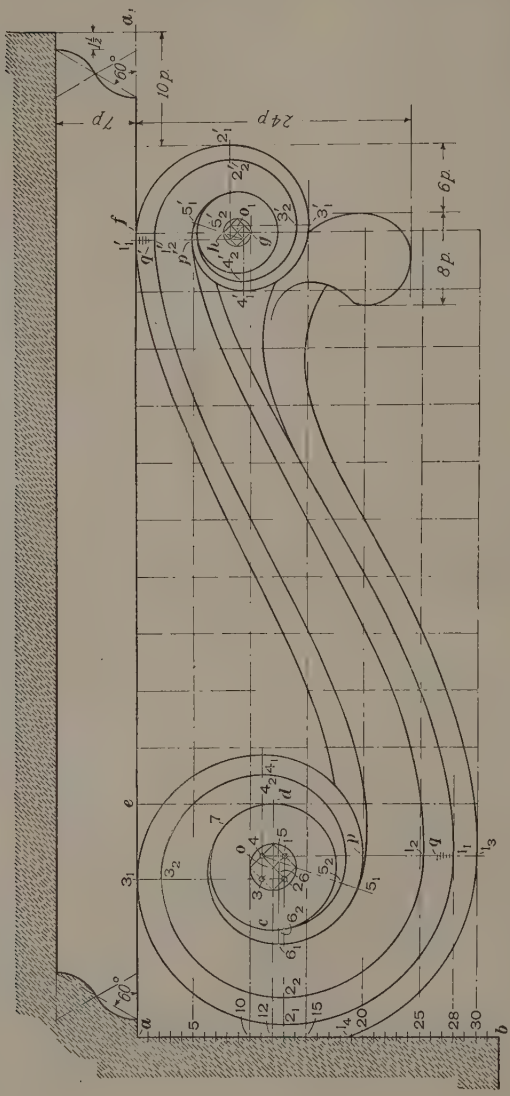


FIG. 17

line through *f* intersects at *g* the horizontal line through *10*. Set off *g h* equal to $2\frac{1}{2}$ parts, obtaining the diameter of the small circle, in which is inscribed a square, similar to that at *o*. In the small square the centres of the quadrants are found in the manner already described with reference to the large volute, except that the volute is inverted; the circle representing the eye has a diameter of 7 parts.

63. Proceeding again with the large volute, Fig. **17**, define the width of the band, or fillet, at 1_1 by making the distance 1_1–1_2 equal to one-third the distance 1_1 p. The width of the fillet diminishes gradually up to the joint 6_1, when the inner volute will be tangent to the eye at 6_2. Set off the distance 6_1–6_2 from 1_1, thus fixing point *q*, and divide 1_1 *q* into 5 equal parts. Then make the width of the fillet at 2_1–2_2 equal to 4 of the parts at *q*, and the width of the fillet at 3_1–3_2 equal to 3 of these parts, and so on to point 6_2, where the inner side of the fillet is tangential to the eye. The band in the small volute is drawn in the same manner, points *p′*, *q′* corresponding to points *p*, *q* in the large volute. The curved fillets connecting the two volutes, and the outline of the curled leaf under the volutes, should be drawn freehand from the dimensions given and with the aid of the system of squares formed by the main horizontal lines and a series of vertical lines between *e* and *f*, spaced at distances equal to 5 parts. The arc 1_3–1_4 of the leaf may be described from *1* with *1*–1_3 as a radius.

64. Now draw the modillion on the plate, as shown in Fig. **7**, placing the top line of the modillion 4″ below the upper border line, and the front of the corona $4\frac{5}{8}$″ from the right-hand border line. Only the outlines of the volutes are drawn, adding the leaves at the right of the large volute.

Place the centre line of Fig. **8**, which is an end elevation of the modillion, at a distance of $3\frac{3}{16}$″ from the right-hand border line, and draw the view from the measurements given and by means of projectors from Fig. **7**.

Now draw Fig. **9**, which is a plan of the cornice with the modillions, looking up, placing the centre line *g h* $3\frac{3}{16}$″ below the upper border line. The necessary dimensions may be obtained from Figs. **1**, **7**, and **8**.

DRAWING PLATE, TITLE: COMPOSITE ORDER

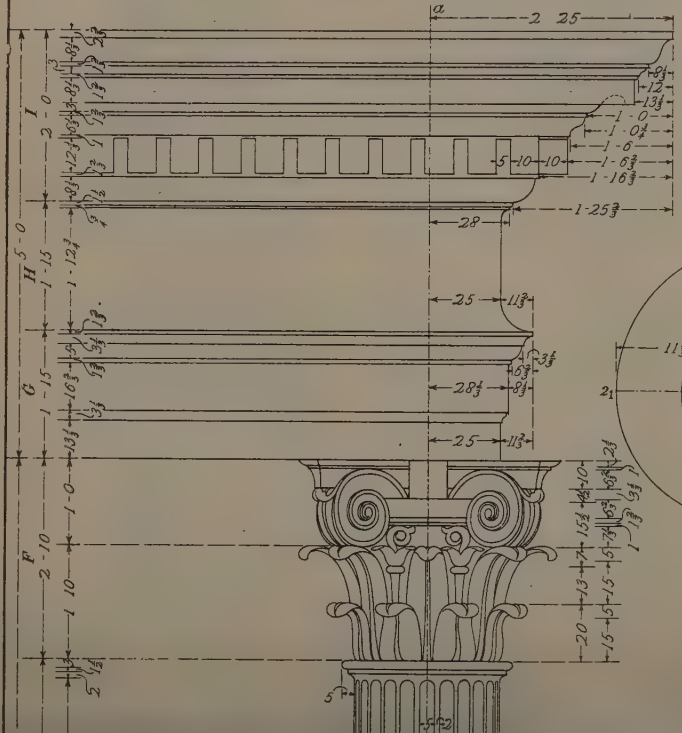
65. The Composite order was invented by the Romans in the endeavour to secure something more elaborate than the Corinthian. It is practically a combination of the Ionic and Corinthian, with proportions nearly identical with the latter, as shown in Fig. 18 of the text.

Construct a scale of modules $\frac{5}{16}''$ above the lower border line making 1 m. equal to $\frac{7}{32}''$. Draw *a b*, the centre line of Fig. **1**, $4\frac{1}{3}''$ from the left-hand border line, and from a point $\frac{3}{4}''$ above the lower border line set off on *a b* a series of measurements fixing the horizontal divisions of the order, and draw the lines defining these divisions. Profile the mouldings of the pedestal, column, and entablature according to the measurements given. Detailed dimensions of the base are given in Fig. 19. Draw the details in the cornice, and complete this view, except the capital of the column and the fluting of the shaft.

66. Now draw Figs. **2** and **3**, the plan of the under side and the angular elevation of the capital. Draw the centre line *a b* $2\frac{1}{4}''$ from the right-hand border line, and draw *g h* $6\frac{3}{16}''$ above the lower border line. With the point of intersection of *a b* and *g h* as a centre and with a radius of 25 p. draw the circular outline of the bell, and with a radius of 1 m. draw the outline of the echinus at the top of the bell. Then draw the mouldings under the echinus and with a radius of 2 m. the circle limiting the projection of the angles of the abacus. Draw the concave sides of the abacus according to the method described for the previous plate ; place the blocks in the centre of the sides, and complete the figure, except the volutes, which must first be drawn in Fig. **3.**

67. Draw *u v*, the upper line of the abacus in Fig. **3,** at a distance of $5\frac{1}{2}''$ below the upper border line. Set off the measurements, fixing the horizontal divisions by means of the dimensions given in Fig. **1**, and draw the lines defining these divisions. Profile the mouldings of the abacus, bell, and astragal, and fix the position of the centre of the eye according to the measurements given. With a radius of $1\frac{2}{3}$ p., describe a circle as the

COMPOSITE ORDER



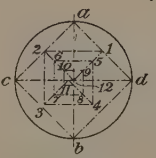


Fig. 8

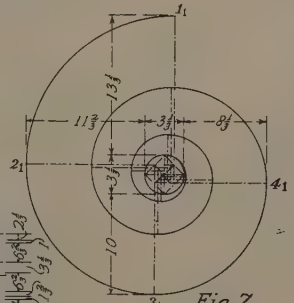


Fig. 7

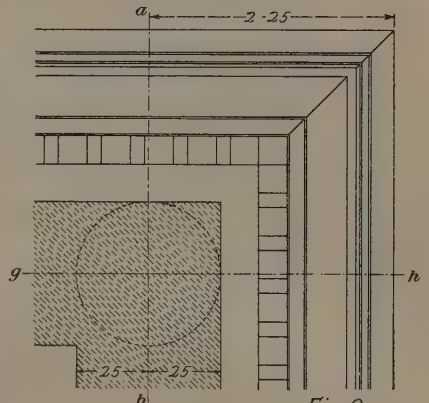
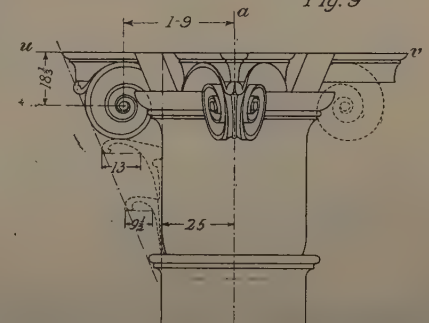
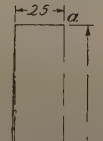


Fig. 9





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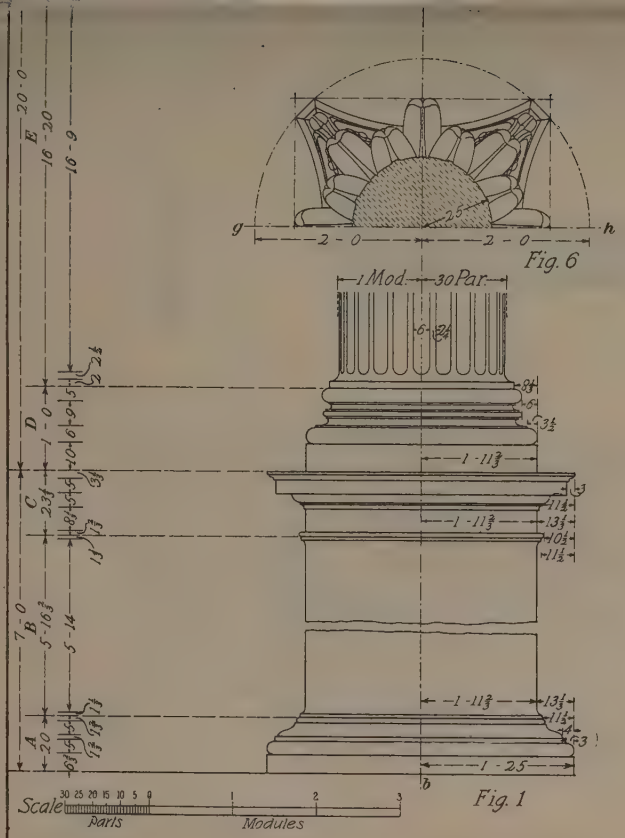


Fig. 1

Fig. 6

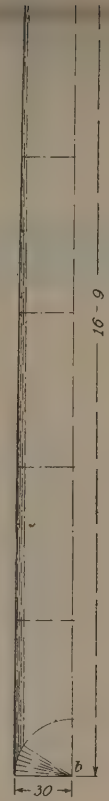


Fig. 5

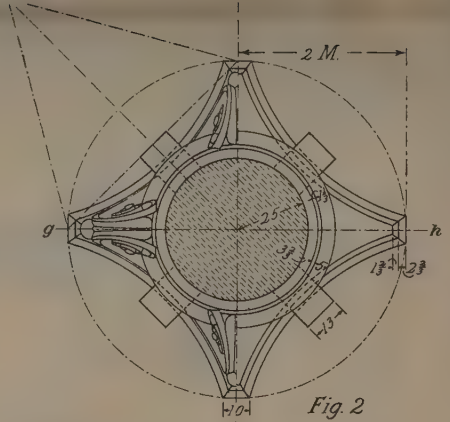


Fig. 2

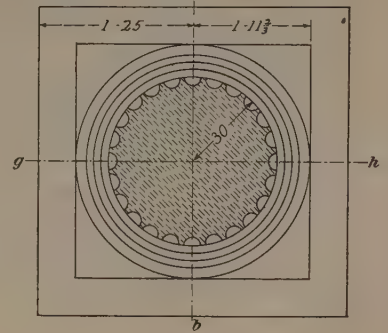


Fig. 4

eye of the volute. The construction of this volute is shown in Fig. **7**, which is drawn to a scale 4 times that of Fig. **3**. But as the construction by means of which the centres of the quadrants are found is difficult to see in this figure, the eye has been shown separately in Fig. **8**, 3 times enlarged. Place the centre of the eye in the latter view at a distance of $2\frac{15}{16}''$ below the upper border line and $5\frac{3}{8}''$ from the right-hand one. Describe the eye with a radius equal to 40 p. on the scale of modules, and draw the centre lines *a b* and *c d*. Then draw the lines *a c*, *a d*, *b c*, and *b d*; bisect *a c* and *a d* in points *2* and *1*, respectively, and draw radial lines from these points to the centre *12* of the circle. Divide the line *2–12* into 3 equal parts, obtaining points *6* and *10*. Through points *2*, *6*, and *10* draw lines parallel to *c d*; the vertical distance between the lines *2–1* and *c d* will then also be divided into 3 equal spaces. Now draw the line *3–4* at a distance from *c d* equal to $2\frac{1}{2}$ of these spaces; from points *2* and *5* draw vertical lines defining the points *3* and *4*. From the latter points draw lines at 45° to *3–4*, intersecting on line *c d*. Draw verticals from *6* to *7*, *10* to *11*, and *9* to *8*, and horizontals from *7* to *8* and *11* to *12*, thus completing the

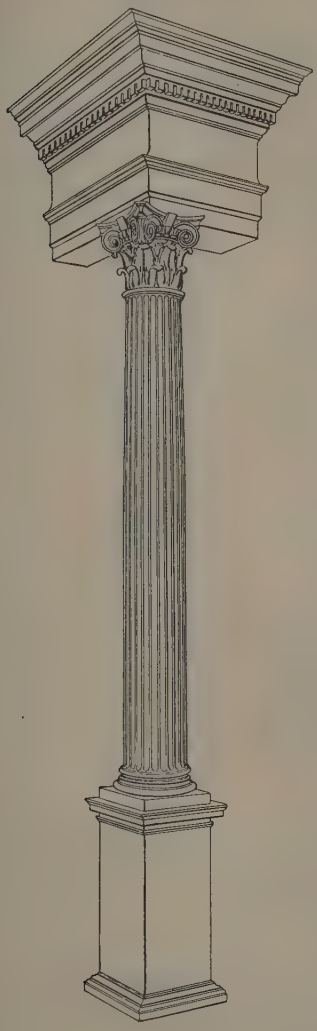


Fig. 18

figure. The centres for drawing the quadrants of the volute are at *1*, *2*, *3*, *4*, etc., and will be used in the order in which they are numbered.

68. Place the centres in the eye of Fig. **7** by the method followed in Fig. 3 and proceed to draw the quadrants. From a centre corresponding to the centre *1*, in Fig. **8**, with a radius equal to 1–1_1, draw the arc 1_1–2_1; from centre *2*, with a radius equal to 2–2_1, draw the arc 2_1–3_1, and continue thus until the outer line of the volute, as shown in Fig. **7**, is complete. Before drawing the inner line of the fillet of the volute, which gradually diminishes to a point where it unites tangentially with the eye, it will be necessary to define its width at the end of each quadrant. This is done in the manner shown by means of Fig. 10. After these widths have been set off on the horizontal and vertical lines limiting the quadrants, the centres for the inner quadrants are found in the same manner as shown in Fig. 10.

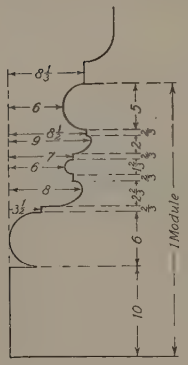
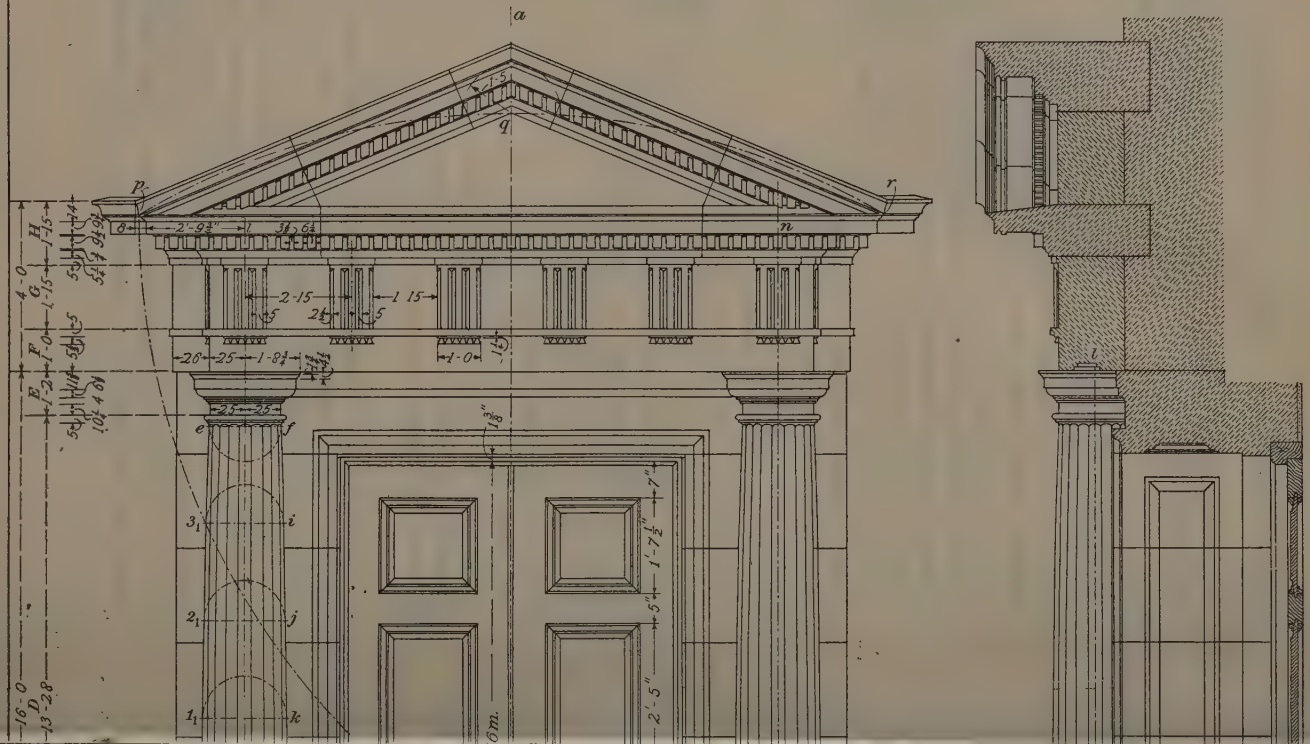


Fig. 19

69. Now complete the volute on the left-hand side of Fig. **3** and project the principal points of its curves to the plan, Fig. **2**. Draw the plan of the volutes in Fig. **2**, and project the principal points of the curves in plan to intersect with lines drawn from similar points on the volute at the left-hand side of Fig. **3**. Through these points of intersection draw curves to represent the volutes at the centre line of Fig. **3**.

Figs. **2** and **3** may now be completed, also the capital in Fig. **1**. The plan of the capital, Fig. **6**, may be traced and transferred from Fig. **2**, the leaves being drawn in, according to the projections figured for them in Fig. **3**. Complete Fig. **6**, and project the details to the capital in Fig. **1**. Then draw the plan of the base, Fig. **4**, placing *g h* $2\frac{1}{4}''$ above the lower border line, and draw the entasis of the shaft, as shown in Fig. **5**, according to the method previously described, also the entasis of the flutes. Place the centre *a b*, Fig. **5**, at a distance of $5\frac{1}{2}''$ from the right-hand

RENAISSANCE DOORWAY



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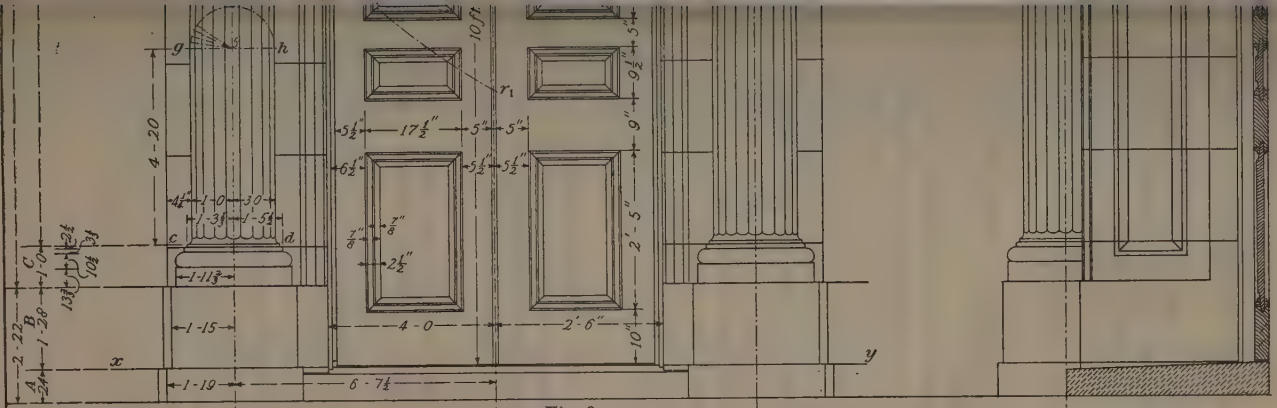


Fig. 2

Fig. 3

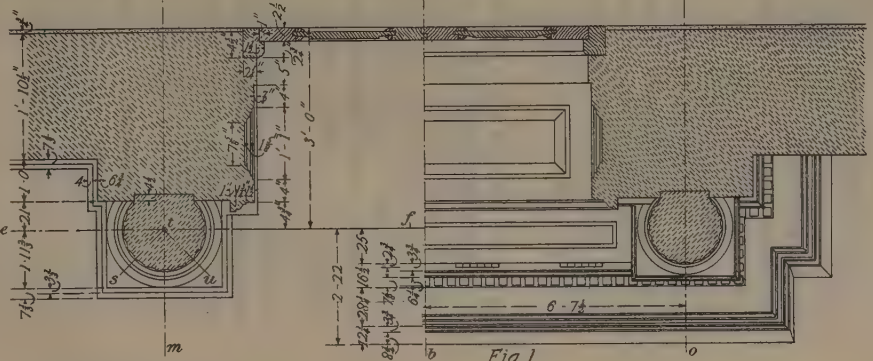


Fig. 1

Scale 30 15 0 1 2 3 4 5 6 7 Parts Modules

Scale 12 9 6 3 0 1 2 3 4 5 Feet

border line, and draw this view to a scale of 1 m. = $\frac{9}{16}$″. Now complete Fig. **1**, drawing the flutes from Figs. **4** and **5**. Then draw Fig. **9**, placing *a b* $3\frac{1}{8}$″ from the right-hand border line and *g h* $3\frac{3}{4}$″ below the upper border line. Complete the plate with all dimensions and dimension lines

DRAWING PLATE, TITLE: RENAISSANCE DOORWAY

70. In the fifteenth century a movement began in Italy to revive the classic orders and apply them to the requirements of the time. This style of architecture has been termed **renaissance,** meaning *rebirth.* The drawing plate shows a plan, elevation, and section of a stone doorway to which the Roman-Doric order is applied and adapted to meet the requirements of modern work. The drawing of the three views should be carried along together, so that details of one may be projected to another. Draw a scale of modules $\frac{1}{4}$″ above the lower border line, making 8 m. equal $3\frac{5}{16}$″. As some of the measurements are given in feet and inches, it is necessary to construct a scale of feet, as shown, making 5′ equal to 8 m.

71. Begin with Fig. **2,** the elevation of the doorway, and draw the centre line *a b* at a distance of $4\frac{7}{8}$″ from, and parallel to, the left-hand border line ; then draw the floor line *x y* at right angles to *a b*, at a distance of $4\frac{7}{8}$″ above the lower border line ; the door opening being 5′ wide, set off 2′ 6″, or 4 m., on each side of the centre line *a b* and draw the jamb lines. Then draw the head of the door opening at a distance of 16 m. above the floor line.

Draw the centre line *l m* of the column at a distance of 6 m. $7\frac{1}{2}$ p. from, and parallel to, the centre line *a b* ; then mark a series of points on the centre line *l m*, representing the principal divisions of the order, beginning at *x y*, the floor line ; mark a point, and draw the ground line at a distance of 24 p. below it ; then, above it, mark, for the height of the plinth *B*, 1 m. 28 p. ; for the base of the column *C*, 30 p. ; for the shaft of the column *D*, 13 m. 28 p. ; and for the capital of the column *E*, 1 m. 2 p. ; for the architrave *F*, 1 m. ; and for the frieze and cornice *G* and *H*,

each 1 m. 15 p. Through these points draw the horizontal lines that define the members.

Now draw the line *g h* at a distance of 4 m. 20 p. above the top line of base *c d*, and on *g h* set off 30 p. each side of the centre line *l m* ; draw the vertical lines down to the base parallel to the centre line *l m*. Complete the profile of the base and plinth of the column as shown, the principal dimensions being figured ; others may be obtained by scale measurement. Draw the capital of the column, placing the neck lines 25 p. each side of the centre line *l m* ; draw the mouldings under the neck of the capital down to line *e f*.

72. Draw the profile of the entablature as shown, the mouldings being drawn freehand ; set off and draw the triglyphs on the frieze, the guttæ of the same on the architrave, and set off and draw the dentils on the bed mould of the horizontal cornice.

To determine the pitch of the pediment describe an arc from the point *r*, at the lower angle of the crown mould of the cornice, with a radius equal to the length of the fascia fillet *p r*, which is 17 m. 17 p., intersecting at r_1 with the centre line *a b* ; from this point as a centre, and with the same radius, describe the arc *p q r* ; then, from the point *q*, with a radius equal to the depth of the cornice less the crown mould, 1 m. 5 p., describe the arc as shown ; from the point *p*, and tangent to this arc, draw the line of the fillet below the crown mould ; parallel to this line draw the lines of the crown mould from the angles of the horizontal moulding ; make the fascia, fillet, and bed-mould members the same width as those of the horizontal cornice, measuring, however, on a line at right angles to the pitch line of the pediment ; the dentils of the pediment cornice are immediately over those of the horizontal cornice, so that their position can be projected from them.

The column, entablature, and pediment having been drawn on the left of the centre line *a b*, duplicate the work to the right of the line, first drawing the centre line of column *n o* and proceeding as before. This being done, draw the architrave round the door opening and the piers situated behind the columns,

as shown in Fig. **1** ; draw the plinth and base lines of the piers and return the entablatures against the main walls.

73. Now draw Fig. **1,** which are half-plans of the doorway, that to the right being one looking up, taken on the level of the line *g h*. First draw the line *e f* through the centres of both columns at a distance of 2″ above the lower border line. Extend the centre lines *l m* and *n o* so as to serve as centre lines for both columns in the plan. From the points of intersection of these lines with the line *e f* as centres, and with radii of 30 p., describe circles representing the plans of the shafts. At a distance of 21 p. from line *e f* draw the face line of pier in the left-hand half-plan, and, at a farther distance of 30 p., the face line of the wall ; draw the jamb line of the door opening and the return of the pier. Draw the curves that represent the moulded members of the base, the radii being procured from Fig. **2** by means of the compasses, with a centre on the line *l m*. In a similar manner, transfer the measurements of the base and plinth blocks ; draw the architrave and the panel and moulds of the jamb or reveal of the door opening. This being done on the left of the centre line *a b*, the work may to some extent be duplicated to the right of this line. In the right-hand half-plan the architrave and cornice must be drawn from the dimensions given, also the capital, Fig. **1,** containing some of the required measurements. The sunk panel in the soffit of the architrave is shown in section in Fig. **3.**

74. Next draw Fig. **3,** which is a vertical section of the doorway on the centre line *a b* of Fig. **1.**

Draw the centre line of the column *l m* at a distance of $2\frac{7}{16}''$ from the right-hand border line ; then project the horizontal lines of the order from Fig. **2,** profile the column and entablature by measurements transferred from Fig. **2,** working from the centre lines of the columns of each figure ; observe that the face of the panel of the pediment is in line with the faces of the architrave and frieze, and that the full lines which subdivide the section-lined area represent the size of the stones composing the structure. Draw the joint line of the jamb adjacent to the base of column, after which divide the distance between this line and

the head into 6 equal parts and draw the joint lines; the distance between the head and the line $x\,y$ is $10'\ 1\frac{3}{8}''$. Then project these lines to the piers of Fig. **2**. Draw the joint lines across the face of the pediment cornice and horizontal cornice, as shown on Fig. **2**, observing that these lines are at right angles with their respective members; project the pediment cornice-joint lines in Fig. **2** over to Fig. **3**.

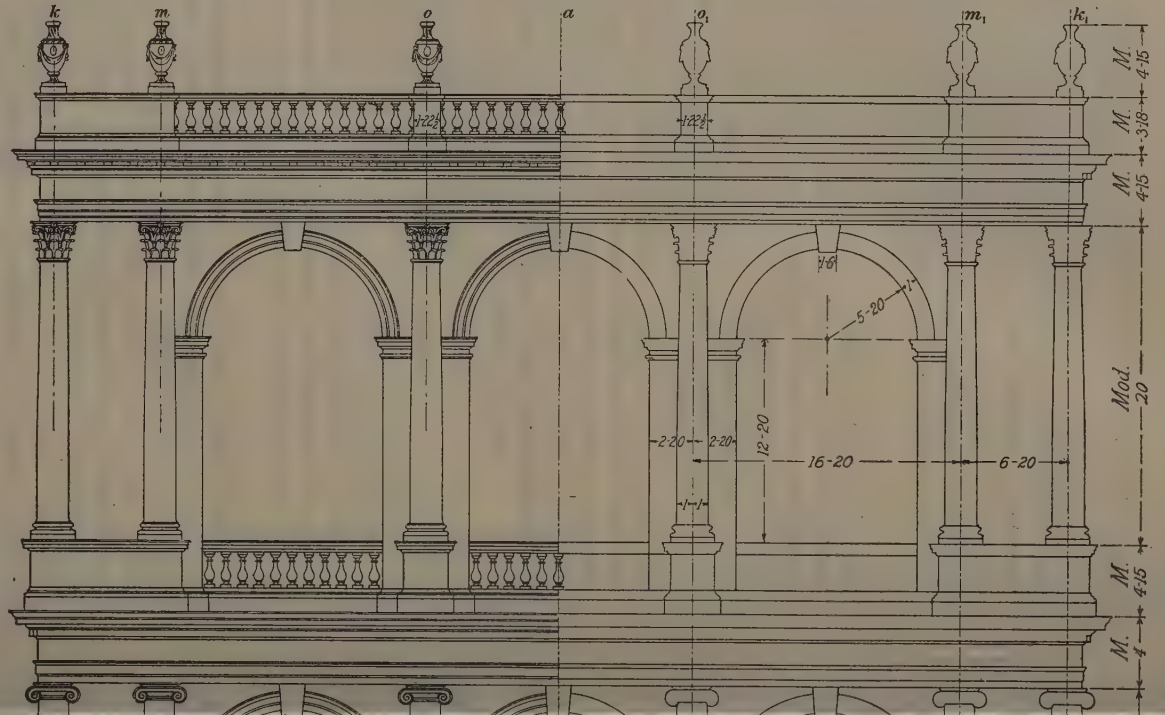
75. To draw the flutings of the shafts, begin by drawing from t, the centre of the left-hand column in Fig. **1**, the diagonal lines $t\,s$ and $t\,u$, each at an angle of 45° from the axial line $e\,f$. Divide the angle of 90° contained between these lines into 5 equal parts of 18° each, and draw the radial lines of division; the intersection of these lines with the arc defining the shaft will give the positions of the arrises between the flutes.

To describe the curve of the flutes, set the bow-pencil to the chord of the arc between the angles of the flutes and then from each angle describe an arc. The intersection of these arcs defines the centre from which the curves of the flutes may be drawn with the same radius. One-third of the shaft having been filled in, the remainder can be drawn in a similar manner.

76. As the sides of shaft between lines $g\,h$ and $c\,d$ in Fig. **2** are perpendicular, and of the same diameter as shown on the plan in Fig. **1**, the lines of the flutings of this section can be projected from Fig. **1**. But, in order to determine points for the curved outlines of the flutings between lines $e\,f$ and $g\,h$, the semicircles that have been drawn on the lines $e\,f$, $3_1\,i$, $2_1\,j$, and $1_1\,k$ to profile the entasis should be divided similarly to the plan of the shaft in Fig. **1**.

Having marked the arrises of the flutes on each semicircle, project the points by vertical lines intersecting their respective diameters $1_1\,k$, $2_1\,j$, and $3_1\,i$. The points of intersection will give the desired points on the curved outline of each flute. Draw through the points, by the aid of a flexible strip, the curves of the entasis. The curved stops of the flutes at $e\,f$ and $c\,d$ can now be drawn. Transfer the various points over to the shaft on the right of centre line $a\,b$, and also to the shaft in Fig. **3**, and complete the flutings.

THE ORDERS APPLIED



CORINTHIAN SCALE.

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77. The design having now been developed by means of the proportional scale and measurements, the drawing will be completed by means of the foot-scale. Proceed to finish Fig. **1**; draw the inner face line of the stone wall, draw the door frame, which is $5\frac{1}{4}''$ wide, draw the door, which is $2\frac{1}{2}''$ thick, and set off the framing, mouldings, and the panels, all of which are shown in section. The dimensions of the framing and mouldings can be procured from Fig. **2**. Observe that the door is in two leaves, the central joint being rabbeted. Draw the door elevation in Fig. **2** by projecting the vertical lines from Fig. **1**; make the lower rail 10″ wide, the lower panel 2′ 5″ high, and so on to the top of the door. Draw the details of the panels as shown. The drawing can now be inked in, section-lined where shown in section, the dimension and centre lines drawn, and the dimensions neatly written. The reference letters may be omitted.

DRAWING PLATE, TITLE: THE ORDERS APPLIED

78. The arrangement by which several orders are placed above one another is called **superposition.** It was used in the Roman amphitheatres and is employed in modern design. The more solid forms of the Tuscan and Doric orders are naturally placed below, and the Ionic and Corinthian above. Even when the same order is employed in the different stories, it is advisable to have the upper columns of smaller diameter than those below, and all the dimensions are diminished accordingly to give the impression of lightness. This is still more the case when different orders are superimposed; otherwise the Doric and Corinthian stories would overpower the Tuscan or Ionic, if the latter were placed below. It is therefore customary to make the upper diameter of each shaft equal to the lower diameter of the one above it, as if they constituted a single tapering column.

79. The façade shown on this drawing plate is composed of three Roman orders, Doric, Ionic, and Corinthian. As details of these orders were given in the preceding plates, it is now possible to realize the value of the parts when assembled in a general

design. In order to obtain satisfactory results with this plate, it is essential that the most careful attention be given to the placing of the centre lines and the principal lines that define the divisions of the orders.

By reason of decreasing the diameters of the columns in each superimposed story, it is necessary to use a different scale of modules for each order. As the upper diameter of a shaft is five-sixths of the diameter at the base, it follows that, if the lower diameter of each shaft is to be equal to the upper diameter of the shaft below it, the scale employed in the second story must be five-sixths of that used in the first. Likewise must the scale used in the third story be twenty-five thirty-sixths, or about two-thirds that in the first story. This ratio is not always adhered to, the modern designer varying it as the circumstances may require. Thus, in this drawing plate the module used for the third story is nine-tenths of the second story instead of five-sixths.

80. Begin by drawing the centre line *a b* at a distance of $6\frac{1}{2}''$ from the right-hand border line, and the base line *i j* $\frac{3}{4}''$ above the lower border line. Before proceeding farther, it is necessary to draw the scales of modules required for the three orders. For this purpose draw a vertical line $\frac{3}{4}''$ from the left-hand border line on which the scales may be set off, letting each scale be opposite the order to which it refers. To construct the Doric scale, set off $3\frac{5}{16}''$ and divide this length into 16 equal parts, which will be modules. For the Ionic scale, take a length equal to 10 of these modules and divide it into 12 p., making 12 m. of the Ionic scale. Add enough parts to make 18. To construct the Corinthian scale, take a length equal to 15 m. on the Doric scale and divide it into 20 p., giving 20 m. on the Corinthian scale.

81. Draw *c d*, the top of the plinth line of the Doric order, $1\frac{1}{2}$ m. above *i j*. Then draw *g h*, the upper line of the column at a distance of $16\frac{1}{6}$ m. above *c d*, and, finally, *e f*, the upper line of the entablature 4 m. above *g h*. The Doric order is included between the lines *i j* and *e f*, and the Doric scale applies only to this portion. Divide the entablature into architrave,

frieze, and cornice, as shown, and draw the horizontal lines defining these parts. Draw the vertical centre lines $k\,l$, $m\,n$, and $o\,p$, and the corresponding centre lines $k_1\,l_1$, $m_1\,n_1$, and $o_1\,p_1$ at the right of $a\,b$. In practice, the whole drawing is first finished in the manner shown at the right of centre line $a\,b$, that is, only the contours of the orders are indicated. Subsequently the details are added, as in the left-hand half of the drawing plate, and the whole drawing finished in that manner. For the purpose of making this plate, however, it should be drawn in the same manner as the drawing plate, only finishing one-half.

82. Commencing at the point of intersection of the line $e\,f$ with the vertical centre line $k\,l$, mark a series of points on the line $k\,l$, defining the vertical subdivisions of the cornice and architrave of the entablature, the capital, and the base of the column, procuring the measurements from the drawing plate entitled *Doric Order*. Draw horizontal lines through the points marked off, and draw the profile of the base of this column, then the profile of the entablature. Next draw the bases, shafts, and capitals of the columns of which $k\,l$, $m\,n$, $o\,p$, $o_1\,p_1$, $m_1\,n_1$, and $k_1\,l_1$ are the vertical centre lines, and draw the plinth blocks under the bases of the columns. At a distance of 10 m. 15 p. above the line $c\,d$ draw the springing line of the arches; then, from the point of intersection of each vertical centre line between the columns with the springing line, and with a radius of 4 m. $7\frac{1}{2}$ p., draw the soffit line of each arch. On the springing line mark a series of points defining the widths of the members of the mouldings of the arch, obtaining the measurements by scaling the drawing plate. Draw these members and the keystones, the sides of which are radial lines. From the intersections of the soffit lines with the springing line project the vertical pier lines. Mark the width of the impost blocks q, which is 30 p., and divide them by scale measurements into fasciæ and cap members, and profile them as shown, and draw the bases of the piers.

83. In order to draw the mutules, triglyphs, and guttæ on the entablature, reference should be had to the plate *Doric Order*. It is noticed that there is a triglyph directly over each column;

the spacing must therefore be $2\frac{1}{2}$ m. from centre to centre of the triglyphs. Draw the triglyphs in the left-hand half of the drawing; the mutules and guttæ may be drawn simultaneously with the triglyphs.

84. The pedestals and balustrade over the entablature of the Doric order properly belong to the Ionic order of the second story and are drawn to that scale. Set off on $k\,l$ a length of 4 m., this being the height of the pedestal; then mark a series of points, defining the vertical divisions of the pedestal, and draw horizontal lines. The cornice and base lines of the pedestal also form those of the balustrade. Set off a length of 18 m. as the height of the column, and 4 m. for the entablature, and draw horizontals through these points. Divide the entablature into cornice, frieze, and architrave by horizontal lines, also the columns into capital, shaft, and base. Proceed to draw the profiles of pedestals and entablature, and draw the volutes of the capitals freehand, though their lower halves may be drawn by a compass to ensure uniformity.

85. It is noticed that the width of the piers is the same in all the orders, but their proportions, expressed in modules, must differ, as the scales are different. The same applies to the arches and keystones, which are all alike. Draw all these parts before proceeding with the balustrade. In order to mark the positions of the centre lines of the balusters, which are spaced at a distance of 1 m., draw short verticals at e_1 and e_2 at a distance of 15 p. inside the two pier lines and divide the distance between e_1 and e_2 into 12 equal spaces. Through the points of division draw verticals, which will be centre lines of the balusters. On one of these centre lines mark a series of points defining the vertical divisions, and draw lines through them for the balusters; then profile the latter. The swell of the body can be drawn by means of the compass, but the other parts must be drawn freehand. Observe that the lower block of each baluster is wider than the upper.

86. The third story is drawn in the same manner as the second, excepting the capitals of the Corinthian columns. In placing

GOTHIC WINDOW

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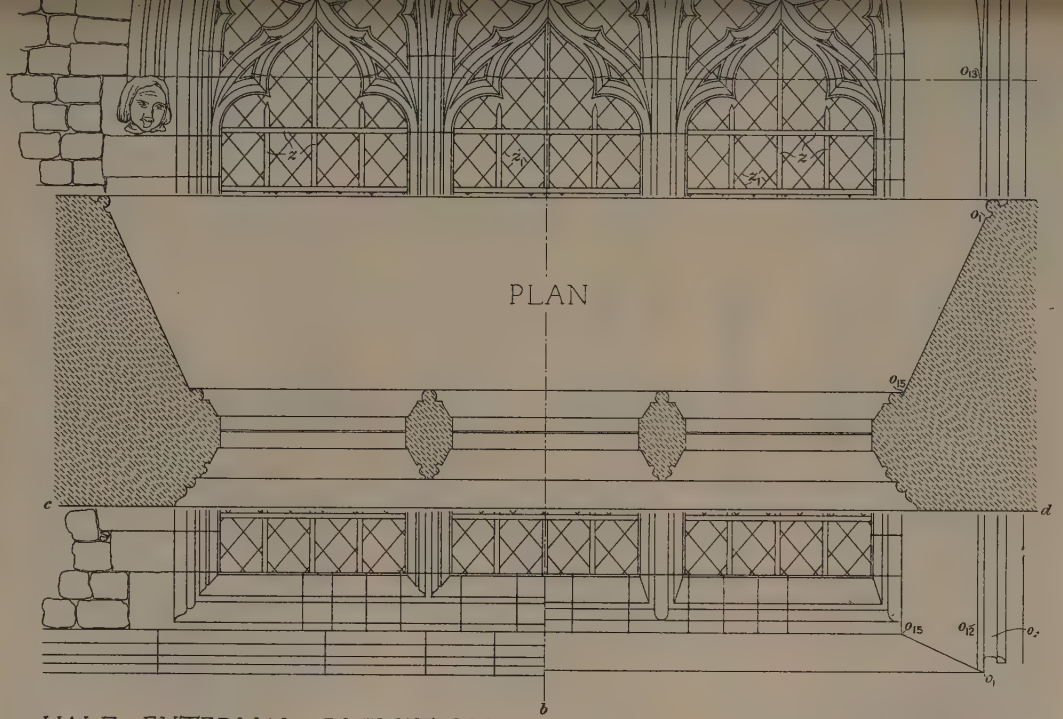


ORIGINAL SCALE - $\frac{3}{4}$ IN. TO 1 FOOT

the centre line of the modillions, observe that they should coincide with the centre lines of the columns and arches over which they occur. The modillions are set at $1\frac{2}{3}$ m. between centres. Make the pedestals for the vases $1\frac{3}{4}$ m. wide, and divide the space between the sides of two adjoining pedestals into 14 equal parts. Through the points of division draw the centre lines for the balusters and draw them in the manner already described. Then draw the vases of which the height has been given ; the other dimensions may be scaled from the drawing plate.

WINDOW TRACERY

DRAWING PLATE, TITLE: GOTHIC WINDOW

87. This plate shows a Gothic tracery window drawn to a scale of $\frac{3}{4}'' = 1$ ft. The drawing consists of an elevation made up of two half elevations, that to the left being an external, and the other an internal, elevation. The elevation is not complete, only the arched part and the sill being shown ; the intermediate part, being a repetition of the portion near the sill, has been omitted, so as not to necessitate making the drawing to a scale inconveniently small.

88. Before proceeding any farther, it is necessary to explain the purpose of the text illustrations that refer to this drawing plate. By reason of the numerous construction lines required to make the tracery of the window, it would be impossible to insert all these on the drawing plate. It would also be impracticable to include them all in a large detail view. The construction lines are therefore distributed over four separate drawings that show the various stages through which the drawing must pass. Fig. 20 is a diagrammatic view showing the main lines of the mullions and the tracery that branches from them. Fig. 21 shows an enlarged plan of the jamb at the right side. In Fig. 22 the mouldings of the mullions have been added, also the main outlines of the cusp-shaped openings. Fig. 23 shows the completed portion of that part of the window situate at the left of

centre line *g h*. It is important that the fundamental lines of the drawing are drawn with scrupulous care, as regard their positions and lengths, if they are straight lines. If parts of a circle, the position of the centre, length of radius, and point of intersection with other arcs must be most accurately set off. If this accuracy

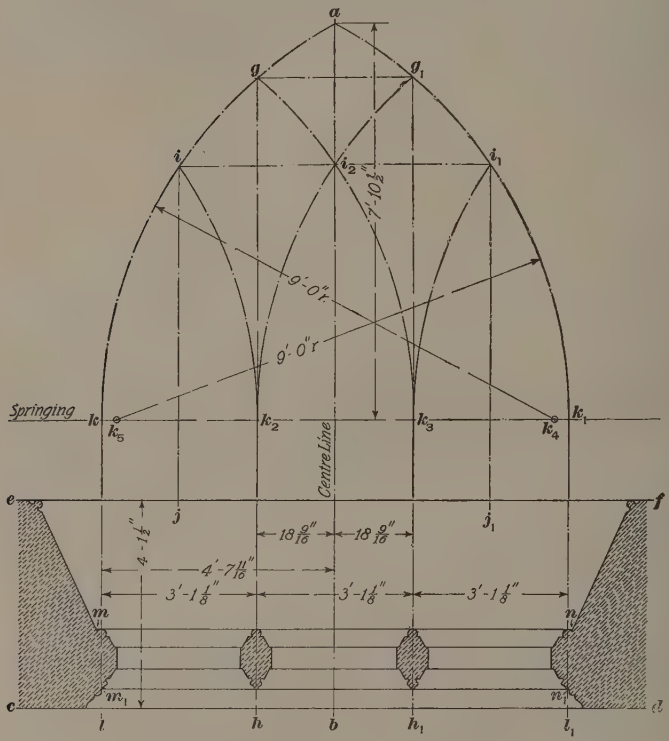


Fig. 20

is not maintained in the beginning, it is impossible to obtain accurate results in the succeeding steps.

89. Begin by drawing a scale at a distance of $\frac{9}{16}''$ above the lower border line. Referring to Fig. 20, draw the centre line *a b* at a distance of $6\frac{1}{2}''$ from the left-hand border line. Before

beginning the elevation, it is necessary to draw the plan, which is drawn to correspond to the external elevation. Draw the face of the outer wall $c\,d$ at a distance of $3\frac{5}{16}''$ above the lower border line and draw $e\,f$ at a distance of $4'\ 1\frac{1}{2}''$ from $c\,d$. The space between these lines represents the thickness of the wall. Now draw the centre lines $g\,h$ and $g_1\,h_1$ of the mullions at a distance of $18\frac{9}{16}''$ from $a\,b$. Also draw the centre lines $i\,j$ and $i_1\,j_1$ at the same distance from $g\,h$ and $g_1\,h_1$, and $k\,l$, $k_1\,l_1$ $3'\ 1\frac{1}{8}''$ from $g\,h$ and $g_1\,h_1$, respectively. Complete now the drawing of the jamb by inserting the moulding, as given in Fig. 21.

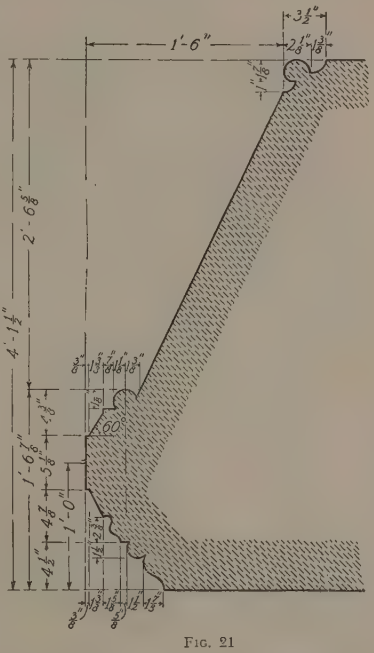


Fig. 21

90. Beginning with the tracery of the window in elevation, draw the springing line $k\,k_1$, Fig. 20, at a distance of $1'\ 7''$ above $e\,f$. Set off from k to k_4 a distance of $9'$, this being the radius of the arc $k\,a$; with k_4 as centre, describe this arc. Then, with the same radius and k_5 as centre, describe the arc $k_1\,a$, both arcs intersecting at a on the centre line $a\,b$. The point a should be $7'\ 10\frac{1}{2}''$ above the springing line. Retaining the same radius in the compass, describe now the following arcs. With k_2 as a centre, describe two short arcs at both sides of k_2 intersecting the springing line at two points; then, with these points as centres, describe the arcs $k_2\,g_1$ and $k_2\,i$. If the drawing has been correctly made, the arcs $k\,i$ and $k_2\,i$ should intersect exactly at the point i of the centre line $i\,j$. The arcs $k_2\,g_1$ and $k_1\,g_1$ should intersect

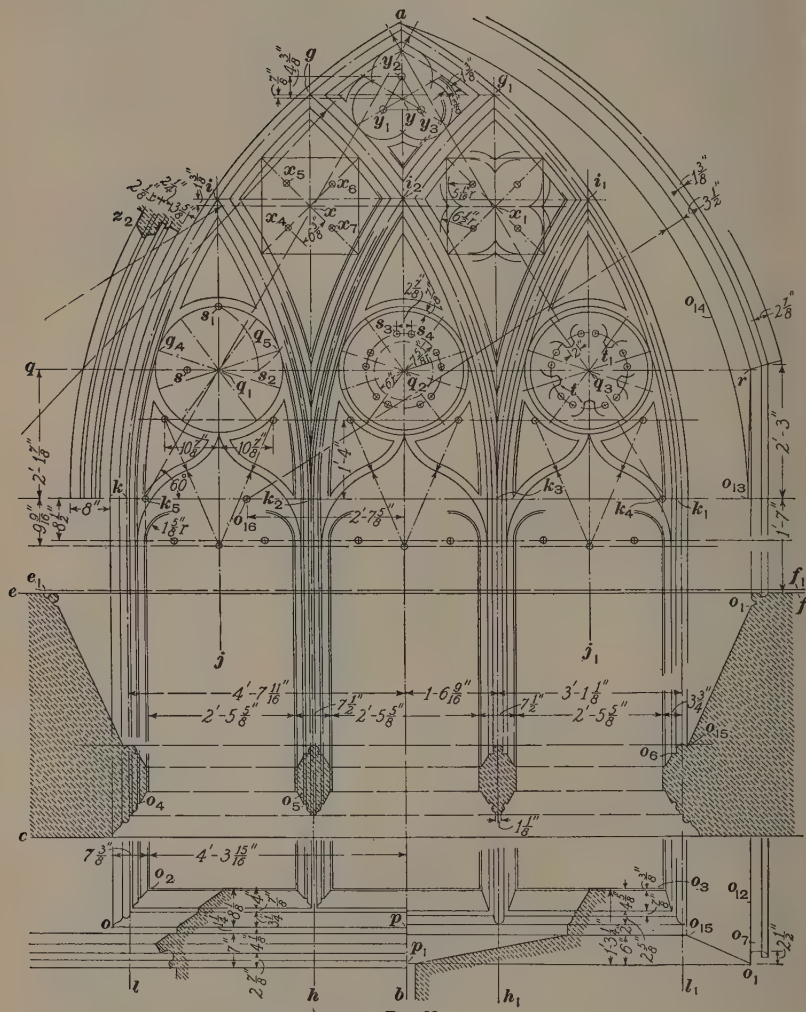
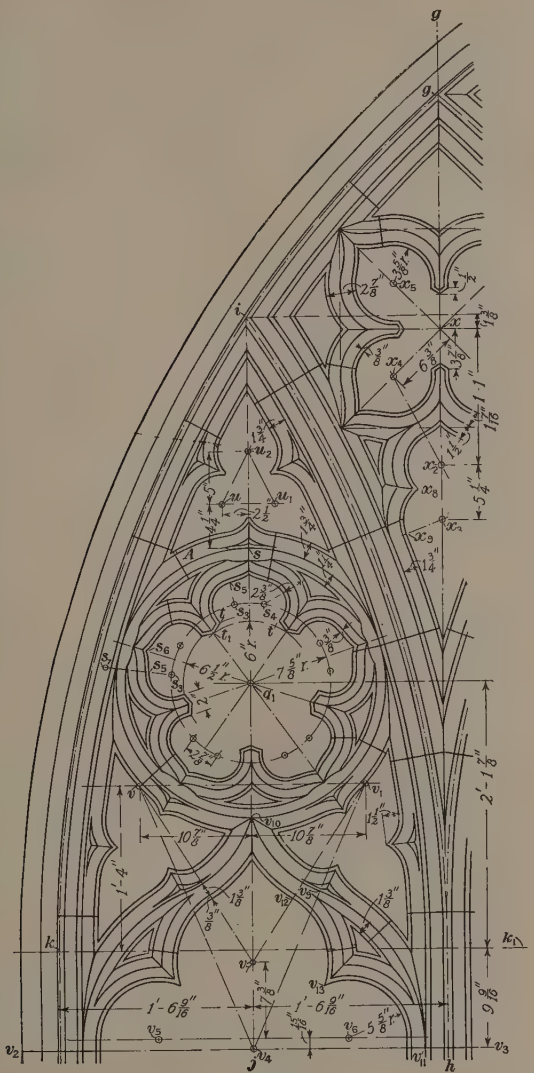

a
g
g_1
y_2
y_1
y
y_3
x_5
x_6
i_2
i_1
x_4
x
x_7
x_1
z_2
s_1
q_4
q_5
s_3
s_4
s_2
q_1
q_2
q_3
o_{14}
r
q_1
k
k_5
k_2
o_{16}
k_3
k_4
k_1
o_{13}
e_1
e
f_1
f
o_1
j
j_1
$4'-7\frac{11}{16}''$
$2'-5\frac{5}{8}''$
$1'-6\frac{9}{16}''$
$2'-5\frac{5}{8}''$
$3'-1\frac{1}{8}''$
$2'-5\frac{5}{8}''$
o_{15}
o_6
o_4
o_5
$1\frac{1}{8}''$
c
$7\frac{3}{8}''$
$4'-3\frac{15}{16}''$
o_2
o_3
o_{12}
o
p
p_1
o_7
o_1
l
h
b
h_1
l_1

FIG. 22


g
g
i
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x5
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u2
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A
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s6
t1
t
a1
v
v1
v10
v12
v5
v7
v13
v6
v2
v3
v4
v11
k
k1
h
j
1'-6 9/16"
1'-6 9/16"
2'-1 7/8"
1'-4"
9 9/16"
10 7/8"
10 7/8"
6 1/2" r.
7 5/8" r.
5 5/8" r.

FIG. 23

at point g_1 on the centre line $k_3 g_1$. The arcs $k_3 g$ and $k_3 i_1$ are described in a similar manner by setting off on either side of k_3 the same radius $k k_4$, thus obtaining their centres. These arcs should also intersect on the centre lines in the manner referred to. If the various points of intersection do not take place at the places indicated on the drawing, the fault must be found and the necessary correction made.

91. Referring to Fig. 22, draw the line $o p$ of the window sill at a distance of $1\frac{3}{16}''$, measured full size, below the line $c d$. From $o p$ the other lines on the window sill may be set off. By measuring from the top plane $o_2 o_3$ of the sill the dimensions may be set off to fix the positions of the lines in the internal elevation, as, for instance, the lower line $o_1 p_1$ of the splay. Having set off these lines, then the various points in the plan are projected down to the elevation of the sill; the points of intersection will determine the positions of the mitre joints between sill, jamb, and mullions. Some of the lines on the jamb and mullions must be drawn with particular accuracy, as they are to be tangent to certain circles in the tracery. Such lines are those proceeding from points o_4 and o_5 in the plan and similar points on the other mullions, also the line from point o_6 on the inside of the jamb. Having completed the elevation of the window sill, draw a horizontal line $e_1 f_1$ at a distance of $6\frac{7}{16}''$ above the lower border line to limit the lower end of the upper part of the elevation. Project the lines of the mouldings on jamb and mullions from the plan to line $e_1 f_1$ and from the points of intersection draw vertical lines to meet the springing line. From here continue the lines as circular arcs having their centres at k_4, k_5 and at the other point situated outside the elevation. Complete the mouldings on the tracery that branch from the mullions in the manner shown on the drawing plate.

92. Draw a line $q r$ at a distance of $2'\ 1\frac{7}{8}''$ above the springing line $k k_1$. The intersection of this line with the centre lines $i j$, $a b$, and $i_1 j_1$ determines the positions of the centres q_1, q_2, and q_3 of the five-leaved openings, called *cinquefoils*. To find the radii of these circles, connect their centres with the centre of the arc to which they are tangent, and produce this line to

meet the arc. For instance, a circle is to be described at q_1 to be tangent to an arc parallel to $k\,a$. Therefore, from the centre k_4 of the latter, draw a line to q_1 intersecting the tangent arc at q_4; the line $q_1\ q_4$ will be the required radius of the circle at q_1. Describing this circle, it should also be tangential at q_5 to the arc representing the line from point o_5 in the plan. The other circles with centres at q_2 and q_3 are drawn in the same manner.

93. To find the positions of the five cusps in these cinquefoils the circles must be divided into 10 equal parts, which may be done in the manner shown in *Geometrical Drawing*. Bisect one of the horizontal radii at s, and with s as centre describe the arc $s_1\ s_2$; then, with s_1 as centre, draw the arc $s_2\ q_5$. The arc $s_1\ q_5$ is one-fifth the circumference of the circle; set this distance off along the circle and bisect these divisions, obtaining the desired number of parts. The dimensions required for drawing the cusps are found in Fig. 23. First draw a circle with 6″ radius fixing the positions of the cusp points, as in the circle with centre q_2, Fig. 22; then draw another circle with a radius of $7\frac{5}{8}$″. On the latter circle the centres of the arcs for the cusps will be set off. For this purpose measure off on each side from the points, where the circle intersects alternate radii, a distance of $1\frac{7}{16}$″, beginning at the upper vertical radii, as shown. The centres s_3, s_4 are first set off and others in the positions indicated.

94. The succeeding operation is shown in the circle with centre q_3. To determine the positions of the angles t on the cusps, draw a circle with a radius of $6\frac{1}{2}$″ and set off on this circle at each side of the cusp centre lines a distance of 1″. Connect the points thus fixed with the points t_1, Fig. 23, the latter points being points of intersection of the centre lines with the circle of 6″ radius, previously drawn. Draw lines corresponding to t, t_1 all round this and the other cinquefoils. With s_3 and s_4, Fig. 23, as centres and $s_3\ t$ as radius, describe arcs similar to $t\ s_5$ all round the foil. The outer end s_5 of each of these arcs is fixed by drawing radial lines from q_1 through the centre s_3, intersecting the arc at s_5. The arc $s_5\ s_6$, required to complete the cusp outline, Fig. 23, could be drawn with a compass by producing

the radius $s_3\ s_5$ and making $s_5\ s_7$ equal to twice the length of $s_3\ s_5$; then, with s_7 as a centre, describe the arc $s_5\ s_6$. On the drawing plate these arcs have been described freehand, so as not to make the drawing confusing by the insertion of too many centre points. The various operations required to complete the three cinquefoils are carried on successively. By means of the dimensions found in Fig. 23 it will be possible to finish the drawing of the tracery in these foils. A perspective view of the block at A is given in Fig. 24. By referring to it an idea will be obtained of the cross-section of the main elements of the tracery.

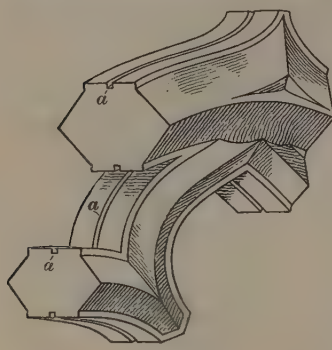

FIG. 24

95. The triangular opening above the block A may now be drawn by setting off from s on $i\ j$ a distance of $4\frac{1}{4}''$; through the point thus found draw a horizontal, and set off on either side of $i\ j$ lengths of $2\frac{1}{2}''$, thus fixing points u and u_1. Above line $u\ u_1$ set off at a distance of $5''$ another point u_2. By means of the centres u, u_1, and u_2 the arcs of the cusps in this opening may be drawn.

96. Proceeding to draw the tracery at the top of the three main openings, draw the horizontal line $v\ v_1$ at a distance of $1'\ 4''$ above the springing line $k\ k_1$, Fig. 23. On the line $v\ v_1$ set off on each side of the centre line $i\ j$ a distance of $10\frac{7}{8}''$, thus fixing points v and v_1. Draw line $v_2\ v_3$ $9\frac{9}{16}''$ below the springing line, the point of intersection v_4 being one of the centres required; then, $\frac{15}{16}''$ above $v_2\ v_3$, draw a line $v_5\ v_6$ on which the centres v_5 and v_6 are to be set off at a distance of $5\frac{5}{8}''$ from the side of the mullion or the jamb. Finally, set off the point v_7 $7\frac{3}{8}''$ above line $v_5\ v_6$ and draw lines from v_4 and v_7 to v and v_1.

Considering only one-half of the tracery in the lower opening, the following arcs may now be drawn. With v_1 as a centre describe the arc $v_{10}\ v_9$, and with v_4 as centre the arc $v_9\ v_{11}$. With

v_1 as centre describe an arc from v_{12} to the top of the opening, and with v_7 as centre the arc $v_{12}\, v_{13}$; then, with v_6 as centre, an arc through v_{13} intersecting $v_{12}\, v_{13}$ at the point v_{13} of the cusp.

97. The two quatrefoils may now be drawn. For this purpose draw line $x\, x_1$ $1\frac{3}{8}''$ below $i\, i_1$, Fig. 22, and at distances of $1'\ 1''$ and $5\frac{1}{4}''$ two other lines fixing points x_2 and x_3, Fig. 23. Through point x draw diagonal lines inclined at 45° to the horizon, and through their points of intersection with the tracery construct a square, as shown in Fig. 22. On its diagonals set off from x distances of $6\frac{3}{8}''$, fixing centre points x_4, x_5, x_6, and x_7. By means of these centres describe arcs defining the cusp-like projections; the arcs that join these curves with the inner angles are to be drawn freehand. Draw the line x_2, x_4, Fig. 23, and with x_2 as centre describe an arc from this line to point x_8. Then, with x_3 as centre, describe another arc $x_8\, x_9$ intersecting the preceding one at x_8. The radii for these arcs must be found by setting off the width of the tracery at the various points from the dimensions given. To find the point x_9 a radial line must be drawn from x_3 to the centre of the arc $i\, k_2$, Fig. 20.

98. To draw the trefoil at the top of the window, Fig. 22, it is necessary to draw a horizontal line $\frac{7}{8}''$ below $g\, g_1$ intersecting $a\, b$ at y. Through this centre point draw two radial lines inclined at 30° to the horizon; then, with a length of $4\frac{3}{8}''$ in the dividers, set off from y the points y_1, y_2, y_3, which are the required centre points of the trefoil.

99. There remain yet to draw the cross-bars, shown in the plate at z and z_1; the centre lines of the vertical bars are found by dividing the open space into 4 equal parts and drawing verticals through the division points. The positions of the horizontal bars are scaled from the drawing plates. The lines z_1 indicating the *lead cames*, which are the grooved leaden strips supporting the glass panes, are drawn at an angle of about 50° to the horizon, and are spaced 4″ apart. When inserting the lead cames, care must be taken to draw these as continuous lines from one side of the window to the other, even if they are interrupted by tracery. The lead glazing is held in position in the stone tracery by means of grooves, shown at *a* in Fig. 24.

100. The lower end of the moulding on the inside of the jamb at o_1, Fig. 22, is of a peculiar shape, and cannot very well be understood without a detailed view. This part is therefore shown in perspective in Fig. 25, where the point o_1 corresponds with a similar point in Fig. 22. At o_7 the moulding is cylindrical, the lower part assuming a square section. The grooves o_8 and o_9 extend behind the part o_7, but while the groove o_8 continues downwards to the level of the splay, the other groove o_9 stops at o_{10}, where it is intersected by an inclined surface. In the elevation the side of o_7 will coincide with the line o_9. The line o_{12} indicates the junction between the plaster and the stone moulding.

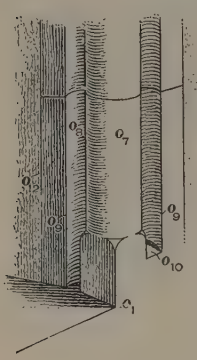

FIG. 25

101. The inclination of the vertical jamb surface $o_1\ o_{15}$, as seen in the plan, Fig. 22, is not maintained throughout its length up to point a. At o_{13} it divides into two surfaces, of which the higher one is more nearly at right angles to the face of wall. The line of intersection between the two jamb surfaces is indicated by the arc $o_{13}\ o_{14}$. The centre of this arc is at o_{16} on the springing line, $2'\ 7\frac{5}{8}''$ from $a\ b$.

At z_2 to the left of the window is the *label moulding*, which is on the outer face of the wall. This moulding serves the purpose of a drip moulding to lead the downward-running water away from the window. It terminates in a label stop, which in this case is given the shape of a human head. Outside of this moulding is a relieving arch built of rubble stone. This should be drawn as shown on the plate and with the same number of stones. Beyond this arch begins the rubble wall itself, which may be drawn approximately as shown.

102. Below the window sill is a sill moulding. A cross-section of the latter and also of the sill are found in the lower part of the elevation. When inking in the drawing plate, the junctions between the blocks in the tracery, the jamb, and the mullions should be carefully drawn in the manner shown.

ARCHITECTURAL PERSPECTIVE DRAWING

ORTHOGRAPHIC AND RADIAL PROJECTION

INTRODUCTION

1. Drawings of objects having three dimensions, length, breadth, and height, may be made to scale by a form of geometrical drawing called projection. There are two principal methods of projection in use, **orthographic projection,** which has already been explained, in which projectors are drawn parallel to one another and at right angles to the plane of projection, and **radial projection,** in which the projectors converge toward a point.

2. When making drawings in orthographic projection it is assumed that the eye is situated, successively, in front of a number of points on the object, and that imaginary lines are drawn from the eye through any one point to a plane so as to be at right angles to the latter. These lines are called *projectors*. If the points of intersection between the projectors and the plane are connected by lines, an outline of the object is obtained. This outline is called an *elevation* or a *plan*, depending on whether it is made on a vertical or a horizontal plane. In Fig. 1 is shown the application of this principle to a small building where the front elevation, side elevation, and plan are shown on three planes to which projectors have been drawn from the several parts of the building.

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In some respects **radial projection,** or **perspective drawing,** is similar to **orthographic projection,** but the plane on which the drawing is made is assumed to be *in front* of the object, instead of behind the object, as is the case with ordinary orthographic projection.

3. It is obvious that the orthographic projection of an object does not represent it as it would appear to the human eye,

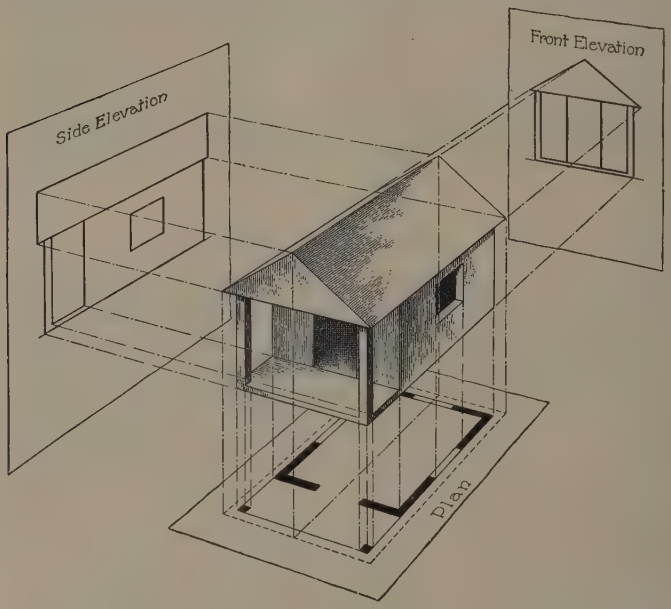


FIG. 1

because in reality the rays passing from the object to the eye are not parallel, but converging. The advantage of orthographic projection is that the projection of every line that is parallel to the plane of projection is of exactly the same length as the line itself; so that to know the length of any particular line on the object that is parallel to the plane of projection it is necessary only to measure the length of the projection.

ISOMETRIC PROJECTION

GENERAL PRINCIPLES

4. Objects shown in orthographic projection are generally so placed that their principal surfaces are parallel either to the vertical or horizontal projection planes. If, instead of this arrangement, the surfaces are so placed as to incline at a certain angle to the projection planes, then the drawing will represent an **isometric** projection. The advantages obtained by placing the object in this particular position are that the resulting projection resembles a perspective drawing, and that therefore one view may suffice where otherwise several may be required. The advantages that isometric projection has over perspective are that it may be more easily made and that the dimensions may readily be obtained from the drawing.

5. The principles of isometric projection cannot very well be explained without applying them to an example. For this purpose the cube, shown in Fig. 2, has been chosen. At (*a*) is shown the plan and at (*b*) the elevation of a cube placed according to the method of ordinary orthographic projection. It will be seen that the cube is standing on a horizontal plane $X\,Y$ and that its vertical faces are, as shown in the plan, inclined to the vertical plane at an angle of 45°. Let it be supposed that the corner d' of the cube retains its position and the cube is tipped forwards so that the diagonal from h' to b' will be at right angles to the vertical plane; then the elevation of the cube on a plane $X'\,Y'$, which is at right angles to both projection planes, will be as shown at (*c*), where the diagonal $h'\,b'$ is seen to be parallel with the horizontal plane $X\,Y$.

6. Considering the fact that the cube has been tilted forwards on the point d' in (*b*), the elevation as shown in (*b*) will no longer be the correct elevation of the cube. The cube is shown in its new position in view (*d*), which is constructed by means of the side elevation (*c*) and the elevation (*b*). In the elevation (*d*) the diagonal $h'\,b'$ is represented by a point, thus proving that

it is at right angles to the vertical plane of projection. The elevation or projection of the cube shown in (*d*) is a true isometric projection of the cube.

7. Characteristics.—It will be observed, in connection with this isometric projection of a cube shown in Fig. 2 at (*d*), that

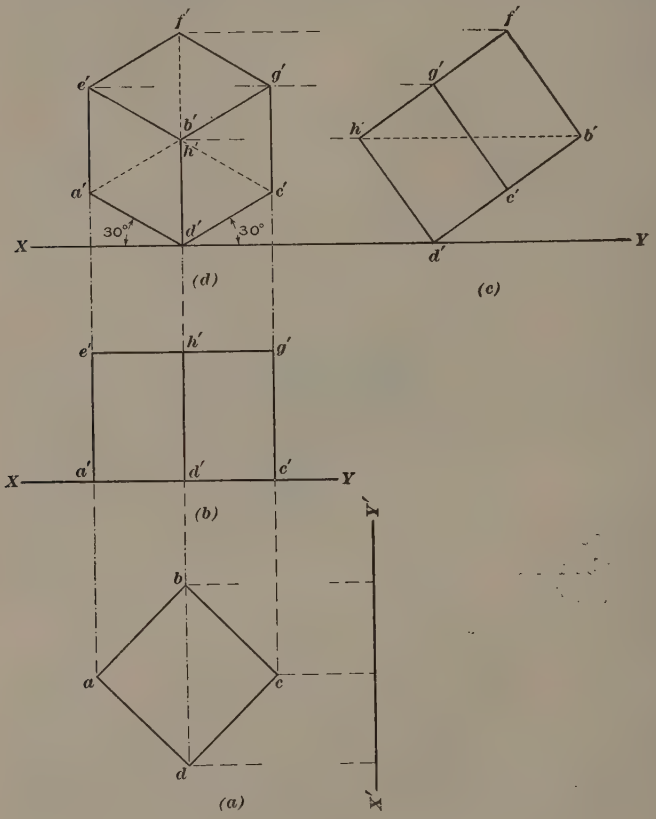


FIG. 2

1. The lines $a'\,d'$, $d'\,c'$, $c'\,b'$, $b'\,a'$, $e'\,h'$, $h'\,g'$, $g'\,f'$, and $f'\,e'$, which are all horizontal in the ordinary orthographic projection

of the cube, as shown at (*a*) and (*b*), are in view (*d*) inclined at an angle of 30° with the horizontal.

2. The lines $a'\,e'$, $d'\,h'$, $c'\,g'$, $b'\,f'$, which are all vertical in views (*a*) and (*b*), still appear vertical in (*d*).

3. If diagonals are drawn from a' to c' and from e' to g' in the bottom and top faces of the cube, they will appear in their true length, because they are parallel to the vertical plane of projection.

4. The lines $a'\,d'$, $d'\,c'$, $c'\,b'$, $b'\,a'$, $e'\,h'$, $h'\,g'$, $g'\,f'$, $f'\,e'$ representing the edges of the cube are not shown in their true length, as they are not parallel to either of the planes of projection.

8. These characteristics belong to all isometric projections, and this form of projection derives its name from the fact that all lines which are at the same angle to a plane are measured to the same scale. The word isometric is derived from two Greek words meaning *equal* and *measure*. To obtain the isometric projection in Fig. 2 (*d*), the projection plane was considered as being vertical and the cube inclined; but exactly the same result would be obtained if the cube remained, as indicated in Fig. 2 (*a*) and (*b*), and was projected on to an oblique plane or a plane inclined at the required angle. The lines $h'\,d'$, $h'\,e'$, and $h'\,g'$ are termed *isometric axes*, as, in a cube, drawn in isometric projection, the sides must be parallel to these axes. Measurement of figures, drawn isometrically, can be made only along lines parallel to the isometric axes.

SCALE

9. Mention was made in Art. 4 of a scale by which to measure the length of lines inclined to the planes of projection. Explanation will now be made of the principles on which such scales are constructed. In Fig. 3, the isometric projection of the cube is repeated, but in addition to this there is also inserted a plan of the upper surface, indicated by the square $e'\,f\,g'\,h$, shown by dotted lines. The line $e'\,f$ represents the true length of one of the edges of the cube, and $e'\,f'$ its corresponding isometric length. If, therefore, a number of units, such as inches, are set off on the line $e'\,f$, and the line $e'\,f'$ is divided into a corresponding

number of parts by the method described in *Geometrical Drawing*, then the line $e'f'$ will represent the required scale by which lines, similarly inclined, may be measured.

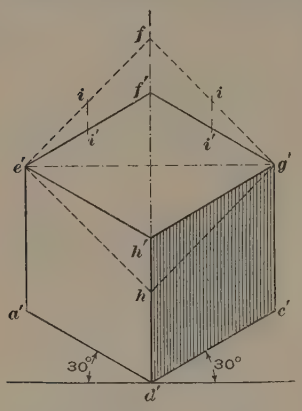


Fig. 3

10. Applying the method described in Art. **9**, let it be supposed that the edge $e'f$ is 2 inches long and that it is divided into equal parts at i. The part $e'i$ will then represent 1 inch. By drawing a line from i parallel to ff', so as to intersect $e'f'$ at i', the line $e'f'$ will also be divided into two equal parts. These parts $e'i'$ and $i'f'$ will each represent 1 inch in length to the isometric scale. This scale applies to all lines in the isometric projection that incline at an angle of 30° to the horizontal or vertical planes. Some of these lines will appear as vertical lines in the elevation, as the lines $a'e'$, $d'h'$, etc., but, as seen from the side elevation, they incline in reality at an angle of 30° to the vertical plane. Any lines that have a different inclination will require a different scale, but it will seldom be necessary to construct such a scale.

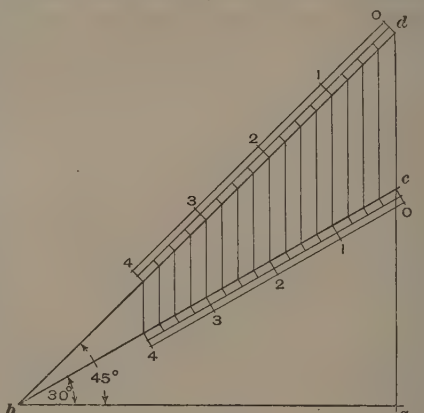


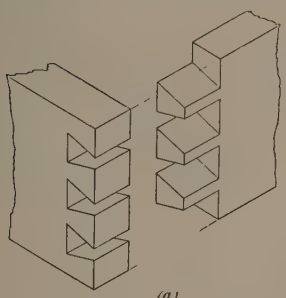
Fig. 4

11. The actual construction of a scale to be used for the principal lines of an isometric projection is shown in Fig. 4. From the point b on the horizontal line $b\,a$ draw lines $b\,c$ and $b\,d$ with an inclination of 30° and 45°, respectively.

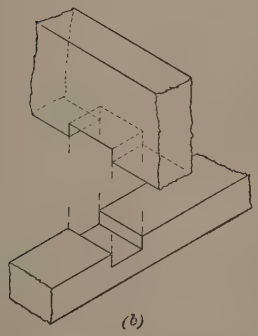
These lines will then correspond with the lines $e'f'$ and $e'f$ in Fig. 3. On the line $b\,d$ mark off a number of inches to full scale, and draw from point d the perpendicular $d\,a$. If now from all the divisions on line $b\,d$ lines are drawn parallel to $a\,d$, the points of intersection with line $b\,c$ will indicate corresponding division points on the isometric scale.

ADVANTAGES OF ISOMETRIC PROJECTION

12. The advantages of isometric projection are that it gives a representation of a body that may be measured to scale, and yet the drawing has an appearance somewhat like a perspective, or true view of the body; and hence it is much more readily understood by persons who are not accustomed to read ordinary projection drawings. It also shows three faces of a solid in one view, whereas plans and elevations, as ordinarily drawn, show only one. It must, however, be remembered that isometric projections do not represent true perspective views, as the projectors are still all parallel to one another.



(*a*)



(*b*)

FIG. 5

EXAMPLES

13. In Fig. 5 at (*a*) and (*b*) are shown two examples of isometric projection representing details of building construction. At (*a*) is shown a dovetailed joint as used in joinery work, and at (*b*) a notched joint between two timbers, frequently found in carpentry work. It will be seen from these two drawings that isometric projection gives a ready means of graphically representing such constructional details by one view only and still with greater

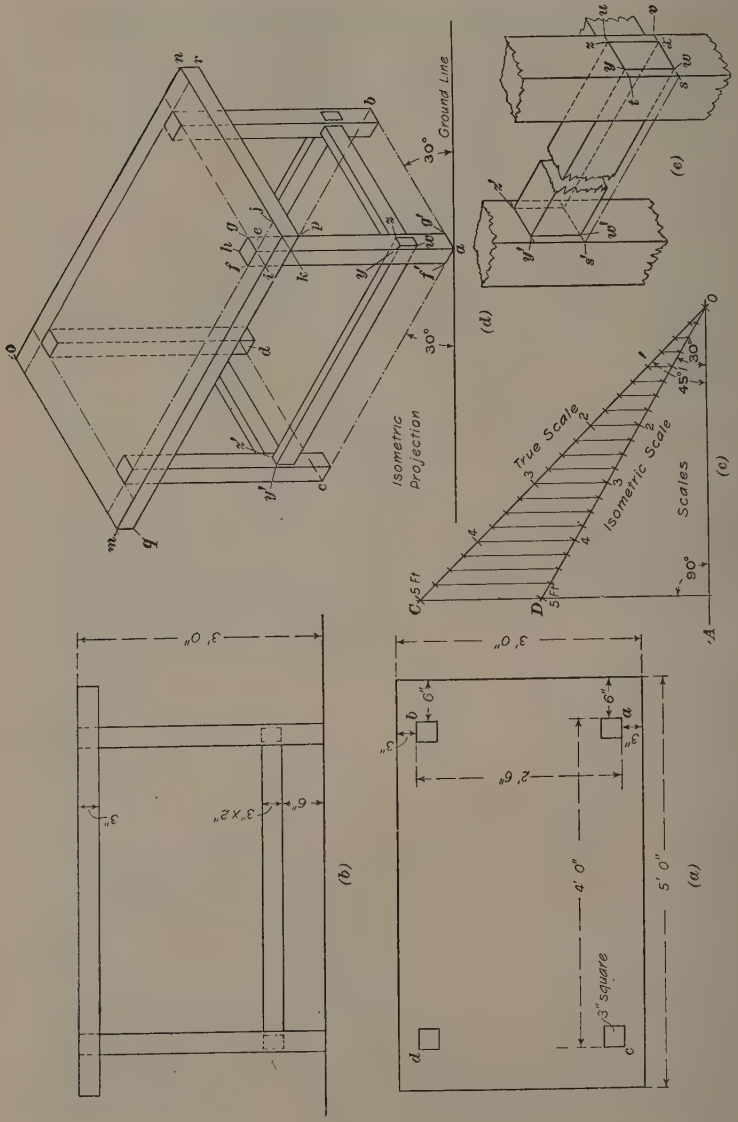

Ground Line
30°
Isometric Projection
(d)
(e)
True Scale
Isometric Scale
Scales
45°
30°
90°
(c)
3' 0"
3"
3"x2"
6"
(b)
3' 0"
6"
2' 6"
4' 0"
5' 0"
3" square
(a)

FIG. 6

clearness than would be possible by several views in ordinary projection.

14. Isometric Projection of a Table.—In Fig. 6 (*a*) is shown the plan of an ordinary wooden table with square legs, and at (*b*) is shown its elevation. Before commencing the isometric projection of this table a scale must be made, as explained in Art. **11.** This scale is shown in Fig. 6 (*c*). From the point *0* on the line *A 0* draw a line *0 C* at an angle of 45° with *A 0*, and set out on this a scale of feet, in accordance with the scale to which the original plan and elevation of the table were drawn in Fig. 6 (*a*) and (*b*). Divide this scale into any suitable number of subdivisions ; the scale is then marked *True Scale*. In this case, each of the subdivisions represents 3 inches.

From *0*, draw, as before, a line *0 D* at an angle of 30° with *A 0*. Next draw from one of the main divisions on the true scale, as point *5*, a line perpendicular to *A 0*. The point at which this perpendicular intersects *0 D* gives the position of the point corresponding to that of *5* on the true scale. Then, from each of the divisions on the true scale, draw lines parallel to line *5–5* cutting line *0 D* at points corresponding to similar points on *0 C*. The subdivided line *0 D* represents the isometric equivalent to the true scale ; this new scale is marked *Isometric Scale*.

15. The scale having been completed, the isometric projection shown at (*d*) may be commenced, all the dimensions in which will be drawn to the isometric scale. First draw a ground line as shown, and at some point *a* draw lines *a b*, *a c* at the inclination indicated. On referring to view (*a*), it will be seen that the outside dimensions over the legs from *a* to *b* and from *a* to *c* are 2 feet 6 inches and 4 feet, respectively ; therefore, make *a b* in view (*d*) equal to 2 feet 6 inches and *a c* equal to 4 feet. On drawing line *b d* parallel to *a c* and line *c d* parallel to *a b*, the point of intersection will give the point *d*.

16. At *a* in (*d*) erect a perpendicular *a e* and make it 3 feet long, according to the dimension given in view (*b*). Draw *e f* and *e g* parallel to *a c* and *a b*, respectively, and make each 3 inches

long ; then complete the top of this leg by drawing lines *f h* and *g h*. Through *f* and *g*, respectively, draw verticals to meet *a c* and *a b* in points *f'* and *g'*. This will complete the drawing of one leg, and the others may be drawn in a similar manner.

17. To draw the table top, produce *g e* and set off *e i* equal to 3 inches ; likewise produce *f e* and make *e j* equal to 6 inches. This gives two points *i* and *j* on the top edge of the table. Through *i* draw *k i m* parallel to *a c*, and through *j* draw *k j n* parallel to *a b*, these lines intersecting at *k*. Make *k m* equal to 5 feet and *k n* equal to 3 feet. Then, from *m* and *n* draw lines *m o* and *n o* parallel to *k n* and *k m*, respectively, the two lines intersecting at point *o*. The drawing of the top surface of the table top is now complete. To obtain the thickness of the table top, draw *k p* vertically and equal to 3 inches in length, and through *p* draw lines parallel to *k m* and *k n* to meet at *q* and *r* verticals drawn from *m* and *n*.

18. The final step is to put in the cross-rails near the bottom of the legs. It will be seen from (*b*) that these bars are 3 inches deep by 2 inches wide, and that their lower edge is at a height of 6 inches from the floor. The bars are shown running into the centre of the leg, so that, as the bars are 2 inches wide and the legs are 3 inches wide, there will be a space of $\frac{1}{2}$ inch on each side of the bar to the edge of the leg.

19. To draw the rails, set off on the edge of the leg *a e* a distance *a s* equal to 6 inches, which will fix the position of the under side of the bars ; likewise set off *s t* equal to 3 inches, which is the depth of the bar. The construction of this portion is shown to a larger scale in Fig. 6 (*e*). Through *s* and *t* draw *s v* and *t u* parallel to *a b* across the face of the leg. In the centre of *s v* at *w x*, set off a distance of 2 inches equal to the width of the rail, and through *w*, *x* draw vertical lines to cut *t*, *u* in *y* and *z*. Then, *y z x w* will form the end view of the bar on the face *a g' g e* of the leg, and it will be found that the edges *y w* and *z x* are each $\frac{1}{2}$ inch from the edge of the leg. From the points *y*, *z*, *w* lines parallel to *a c* may be drawn to the opposite leg whose corner is at *c*.

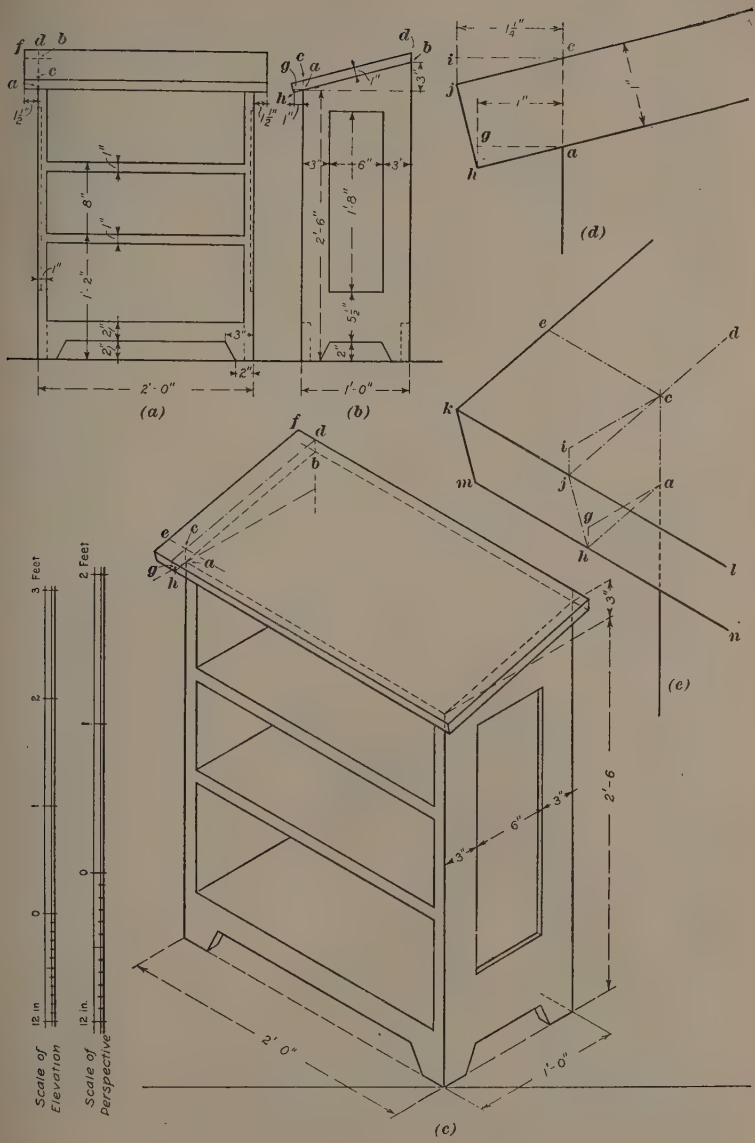

(a)
(b)
(c)
(d)
(e)
2'-0"
1'-0"
2'-6"
1'-8"
1'-2"
8"
6"
3"
2"
1"
1¼"
1½"
5½"
Scale of Elevation
Scale of Perspective
3 Feet
2 Feet
12 in
0
1
2

FIG. 7

20. To find the end points of the lines $y\,y'$, $w\,w'$, etc., draw from the point s on the leg $a\,e$ a line parallel to $a\,c$ to cut the leg at c in s'. The face of the rail is set back $\frac{1}{2}$ inch from the face of the leg, so that a line drawn from s' parallel to $c\,d$ will cut the line $w\,w'$ in w'. Then, w' will be the end point of the line $w\,w'$. Through w' draw a vertical line to meet the line $y\,y'$ in y', and through y' draw a line parallel to $c\,d$ to meet the line $z\,z'$ in z'. The isometric projection of this rail will then be complete, and the other rails may be drawn in a similar manner by finding their end elevations on the faces of the various legs and drawing lines to represent their edges through these points until they meet the faces of the opposite legs.

21. Isometric Projection of a Bookcase.—In Fig. 7 (*a*) is shown the front elevation and at (*b*) the side elevation of a bookcase, drawn to the scale shown beneath the elevations. It is not always necessary to construct an isometric scale from the scale to which the elevations are drawn. In this case it is desired to draw the isometric projection to a larger scale than would be the case if an isometric scale were constructed from the original scale ; so the larger scale is taken as the isometric scale, and all dimensions must be drawn to this scale.

22. The lower portion and shelves of the bookcase can be put into isometric projection in a manner similar to that described with reference to Fig. 6 ; but as the desk top is slanting, a new problem is here introduced. The points fixing the outline of the side of the bookcase in (*b*) must first be found. The isometric position of points a and b in (*b*) may be found in (*c*) by setting up the correct heights of 2 feet 6 inches and 2 feet 9 inches from the bottom of the case. Similar points c and d on the top side of the sloping shelf may be found by making $a\,c$ in view (*c*) equal, according to the isometric scale, to the dimension of $a\,c$ in view (*b*) and drawing $c\,d$ parallel to $a\,b$. Through d draw $d\,f$ equal to $1\frac{1}{2}$ inches to the isometric scale and at an angle of 30° with the horizon. In a similar manner, through c, draw $c\,e$ equal to $1\frac{1}{2}$ inches. Join $f\,e$ and produce it indefinitely beyond the front side of the case. The line $f\,e$ will be the farther top edge of the sloping desk top.

23. The construction by which to find the front edges of the sloping top is shown to a larger scale at (*d*), where similar letters refer to similar points in view (*b*). Through point *a* a horizontal is drawn on which is set off a length *a g* equal to 1 inch, according to the dimension given in (*b*). Through *g* draw a vertical intersecting the line *a h* at *h*, which point indicates the lower front edge of the top. Make the top 1 inch thick, as shown, and draw through *h* a line at right angles to *a h*, intersecting *c j* at *j*. Draw the perpendicular *j i* and through *c* a horizontal intersecting *i j* at *i*. By measuring *c i* it will be found to be $1\frac{1}{4}$ inches, nearly. It is now necessary to repeat this construction in view (*c*) by means of isometrical projection, but as the lines will be very short and close together, the construction has been shown to a larger scale at (*e*) so as to make it entirely clear.

24. Referring to Fig. 7 (*e*), draw *c i* at an angle of 30° to the horizon and make it $1\frac{1}{4}$ inches long ; through *i* draw a vertical intersecting *c d*, produced, at *j*. Then, *j* is a point in the upper front edge of the top. Draw *a g* parallel to *c i* and set off point *g* at a distance of 1 inch from *a*. A vertical through *g* will intersect at *h* the line *a h*, which is parallel to *c j*. Then, *h* is a point in the lower edge. Connect points *h* and *j* by a line, and draw through points *h* and *j* lines *k l* and *m n* parallel to the upper side of the top. Produce *e k* so as to intersect *k l* at *k* and draw from the latter point the line *k m* parallel to *h j*, by this means determining the position of point *m*. The other end of the top can be completed in a similar manner.

RADIAL PROJECTION OR PERSPECTIVE

PRINCIPLES AND USE

25. In radial projection the projectors, as already stated, are not parallel but converge to a point, and they may therefore be taken as corresponding to the rays of light travelling from every point of an object to the eye of a person looking at it. If a transparent vertical plane is interposed between the object

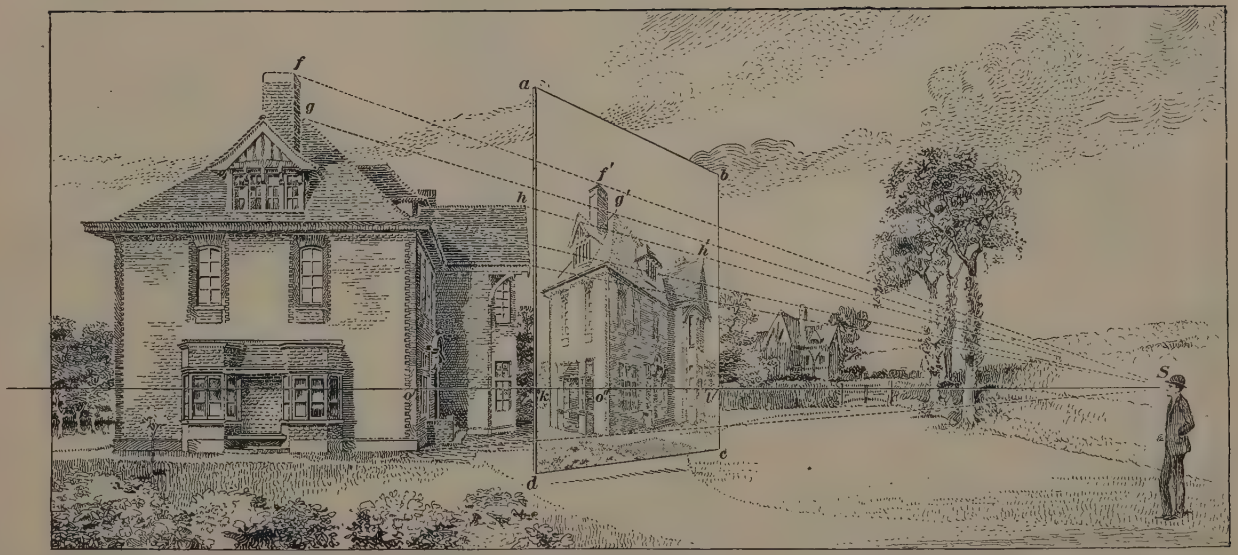


Fig. 8

and the eye, the rays or projectors must pass through this plane to reach the eye. Assuming that at the point where each ray passes through the plane a mark is made, and that all these marks are connected by lines, a drawing is obtained that will exactly represent the object as seen by the eye in the position it occupies. From this it will be seen that by means of **radial projection,** or **perspective,** an exact representation is obtained of the object as seen by the eye. This is the principal value of this method of projection, but it has the disadvantage that it is not possible to scale a perspective drawing in the same way as an orthographic projection.

26. A glance at Fig. 8 will make this description quite clear. *S* is the point to which all the projectors converge, that is, the eye of the spectator, generally spoken of as the *station point;* the plane *a b c d* interposed between the objects viewed and the eye is the plane of projection, generally spoken of as the *picture plane.* The projectors, or rather a few of them, are shown by means of dotted lines, the points whence they originate being marked by letters as *f*, *g*, *h*, etc. The projection of these points on the picture plane is indicated by the letters *f'*, *g'*, *h'*, etc.

As previously remarked with regard to orthographic projection, the projection of straight lines will still be straight lines, so that only the projections of the ends of the lines need be actually found. It may be said, with regard to surfaces, that all objects are bounded by plane or curved surfaces and all surfaces are limited by lines. Therefore, the drawing on paper of these limiting lines, as they appear to the eye, determines the apparent shape and area of any surface, and the grouping of all the visible surfaces bounding an object produces a perspective drawing of that object.

27. It must be remembered, in studying Fig. 8, that the plane *a b c d* with its drawing appears in perspective, and that, therefore, the drawing traced on it is distorted, but it illustrates the principle of radial, or perspective, projection. The line *d c*, which is the intersection of the picture plane and the horizontal ground plane, is known as the *ground line.* The horizontal line *S o'*, which is perpendicular to the picture plane, passes

through the centre of the field of vision, that is, the view included by the eye in one given position. In this instance, the observer occupies such a position that the perpendicular $S\,o'$ does not pass through the vertical centre line of the picture plane, but is to the left of it. The point o' is a projection of the point o on the nearest corner of the house. The line $S\,o'$ is sometimes spoken of as the *principal visual ray*, and the point o' as the *centre of vision*. It also follows that the vertical distance of o' above the ground line $c\,d$ is exactly equal to the height of the eye S above the ground plane, which is here represented by the lawn in front of the building. The picture plane is always vertical and at right angles to the principal visual ray.

The horizontal line $k\,l$ through the centre of vision o' is called the *horizon*. This line is here shown extended in both directions. If the landscape had been open with a view of the ocean in the rear or an open prairie, the horizon line of the ocean or the prairie would coincide with horizon $k\,l$ in the picture plane.

28. What has already been said about drawing to scale applies also to a certain extent to perspective drawing, in so far that a perspective is made from scale drawings, and in setting up the height of the centre of vision above the ground line, the height of the eye must be marked off to the scale selected. This must not, however, be taken to mean that all the lines in a perspective drawing are drawn to a given scale. This is not so, as will appear later, but perspective drawings are, in practice, set up from plans and elevations drawn to scale.

DISTANCE OF OBJECT AND SIZE OF PROJECTION

29. The size of an object, as shown on the picture plane, compared with the size of the object itself will vary, depending on the distance of the object from the eye. Referring to Fig. 9, if it is assumed that lines are drawn from two sides of the sphere $b\,c$ to the eye at e, and that these lines are intercepted by the picture plane $a\,f\,g\,h$, the circular outline connecting the points $b'\,c'$ where the lines $e\,b$ and $e\,c$ pass through the plane $a\,f\,g\,h$ will form, on this intercepting plane, an outline of the sphere $b\,c$.

Let the sphere now be moved to the position $j\ k$; its new projection $j'\ k'$ will be larger than before; if the sphere had been moved farther away, the projection would have been smaller.

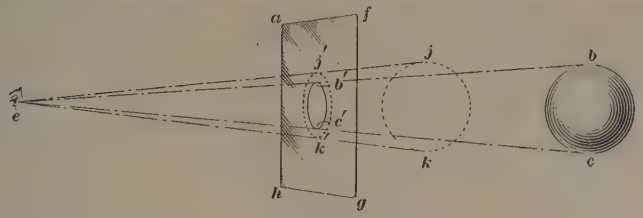


Fig. 9

It will also be clear that if the sphere and the eye had retained their position, and the picture plane been moved, the projection would have been larger when the plane was near the ball and smaller as the plane approached the eye.

Fig. 10

30. In Fig. 10 a perspective view is shown which may serve to illustrate some fundamental characteristics of perspective

drawings. The spectator in this instance is standing midway between the metals of the railway with his eye at some distance above the level of the track. The first thing noticeable is that the two metals of the track and the rails of the fence, as well as the telegraph wires, all truly horizontal, appear to converge and ultimately meet in a point on what is spoken of as the horizon. The point at which the parallel lines meet is called their *vanishing point.* The telegraph poles and the posts of the fence remain vertical in the view and the sleepers of the track remain horizontal; that is, all lines parallel to the picture plane retain their original direction. The description of this perspective view is intended to be only a general one. More detailed definitions of the terms used in perspective will be given farther on.

31. General Rules.—From the foregoing consideration of the characteristics of a perspective drawing, the following rules are deduced. They should be read carefully, as they will be referred to repeatedly in the succeeding examples.

Rule I.—1. *All lines parallel with the picture plane, whether vertical, horizontal, or inclined to the ground line, retain their normal directions in perspective drawing.*

2. *All lines or surfaces of objects in contact with the picture plane appear their full normal size in perspective drawing.*

3. *All lines or surfaces of objects beyond the picture plane appear smaller than normal in perspective drawing.*

Rule II.—1. *All lines not parallel with the picture plane, but parallel with one another, appear to converge as they recede from the eye. The point toward which any set of parallel lines converges is called their vanishing point.*

2. *When the parallel lines are perpendicular to the picture plane* (as the metals, telegraph wires, and fence boards in Fig. 10), *the vanishing point is directly in front of and on a level with the eye; in this position it corresponds with the centre of vision.*

The second part of rule II has not at present been proved, and it may at this point be difficult to understand, but after a careful consideration of the method adopted in determining the vanishing point of any system of parallel horizontal lines, the rule will be found to be correct.

FINDING VANISHING POINTS

32. In Fig. 11 is shown a diagram in which PP is a side elevation of the picture plane, S is the station point, or the spectator's eye, SO the principal visual ray, and AB the ground line. Let there be two horizontal lines ad and eh, one above and one below the line SO. If the projection on the picture plane of successive points along either of these lines is found, and through these projection points a straight line is drawn, the straight line so formed will be the projection of the original line. From a, b, c, and d, successive points along the line ad, draw projectors to the eye at S, fixing the projections of these

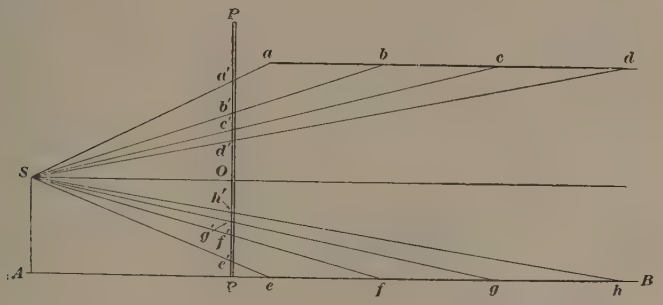


FIG. 11

points on the picture plane at a', b', c', and d', respectively. It will be observed that the farther a point is from the picture plane, the nearer to the level of O is the projection of that point. If a point on the line ad produced could be obtained at an infinite distance from the picture plane, its projection would be at the level O. It is evident, however, that no point on the line ad produced can have its projection below O, and therefore the system of horizontal lines represented by ad will converge and vanish toward a point on the level of O.

33. A similar result, only in the opposite direction, is obtained with regard to the system of lines represented by eh, of which the projections are shown at e', f', g', and h'. These lines

represent horizontal lines without respect to the direction they may have as compared with the principal visual ray. Similar results would be obtained with any horizontal line above or below $S O$, thus proving that all systems of horizontal lines converge to some point on the level of the centre of vision. This level, represented by the horizontal line through O on the picture plane, is called the *horizon*. From these facts the following rule can be formulated :

Rule.—*All systems of horizontal lines have their vanishing points on the horizon.*

34. The method of determining the precise point on the horizon toward which any particular system of parallel lines will converge is shown in Fig. 12, where $P P$ is a plan of the picture plane, S the station point, O the centre of vision, and $a\,c$, $d\,f$, and $g\,h$ three parallel horizontal lines. Consider first the line $d\,f$, and find the projections of one or two points along its length, such as d', which is the projection of d, e' of e, and f' of f. It will be noticed that these points fall farther and farther to the left from the projection of the point d which is nearest the picture plane, and if the line $d\,f$ is produced indefinitely points on the produced part will have their projections still farther to the left. If a point is imagined on the line $d\,f$ produced at an infinite distance, then the ray joining S and that point will be parallel to $d\,f$, and hence the projection of that point will be at V_1, V_1 being obtained by drawing $S\,V_1$ parallel to $d\,f$. The farther away a point is on the line $d\,f$ the nearer will its projection be to V_1, but no point on the line $d\,f$ produced, however far, could have its projection farther to the left than V_1, and therefore the line $d\,f$ will appear to vanish to the point V_1.

35. The same reasoning applies to the line $a\,c$, and also to the line $g\,h$, though that line is beyond V_1 to the left. A similar consideration of the lines $i\,j$, $k\,l$, and $m\,n$ will show that their vanishing point will be at V_2, where $S\,V_2$ is drawn parallel to the lines $i\,j$, $k\,l$, and $m\,n$, and the vanishing point of the lines $q\,r$, $o\,p$, and $s\,t$, which are at right angles to the picture plane, will be at O. This last condition is exemplified in Fig. 10, where the point of convergence of the rails, and wires, and

fence, at an infinite distance, is at the centre of vision on the horizon. A very important rule may be deduced from these facts:

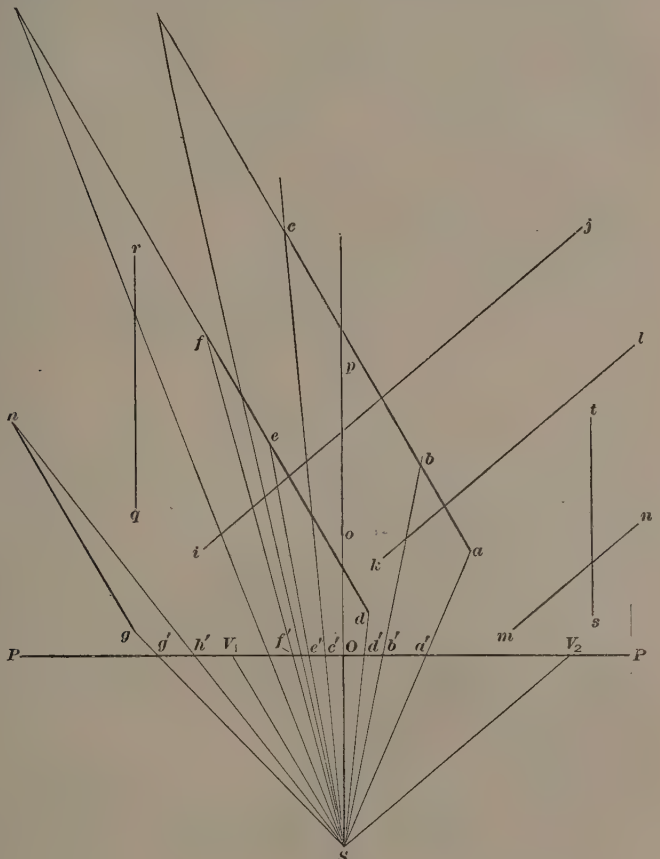


Fig. 12

Rule.—*The vanishing point of any system of parallel horizontal lines is that point where a line through the station point parallel to the lines in question cuts the horizon on the picture plane.*

POSITION OF STATION POINT

36. In selecting a position for the station point, if a perspective view is to be made of a building, two things have to be considered. The first is that a position must be selected which will give a good and favourable view of the building. It is sometimes rather difficult to judge from the plans and elevations which point of view to select so as to give the most advantageous view of the building, but a little experience will greatly assist in determining this point. In important work, it is desirable that a point should be chosen and a perspective of the main lines set up so that the general effect may be seen. If the view is not found satisfactory, the station point should be moved so as to improve the view and another perspective of the general lines and grouping made. As soon as a satisfactory point of view is found the work may be proceeded with.

37. The second consideration affecting the choice of a station point is that the point must not be fixed so near to the object that the rays from the eye to the extreme outlying points to be shown do not include an angle, called *visual angle*, greater than 60°. If this rule is not observed, a distorted view of the object will be the result. If possible, it is much better to restrict the visual angle to a much less amount; and in practice it is customary to fix the station point at a distance from the nearest part of the object to be shown not less than three times the greatest height or width of the object or group of objects to be included in the view. Sometimes it will be found impracticable to choose such a position, but it should be done as far as circumstances will allow it. In perspectives of interiors of buildings, it is frequently necessary to include up to the 60° angle, but for exterior work it is better never to approach such a wide angle. In some cases it is necessary to depict the appearance of a building from some definite position; then, of course, the station point is already fixed.

38. As soon as the station point is fixed, a line is drawn from the station point through the middle, approximately, of that

which is to be included in the view ; this line will be the principal visual ray. At right angles to this ray a line is drawn in the plan to represent the picture plane. The question of how far the picture plane should be from the eye depends entirely on the required size of the finished drawing. The nearer the picture plane is placed to the eye the smaller will be the picture, and the farther away it is placed the larger will be the resulting drawing.

In general, it does not give a very satisfactory drawing to place the station point so that the principal vertical planes of the object to be represented are at angles of 45° with the principal visual ray ; but a definite rule cannot be given as to the best angle which will be applicable to all cases. The angle most suitable for each separate case will depend on the form of the object, and is easily chosen after some experience has been gained in making perspective drawings.

PARALLEL PERSPECTIVE

39. In some instances perspectives are drawn with the principal vertical face of the building or other object parallel to the picture plane. Under these circumstances the horizontal lines of such face do not vanish, as they are parallel to the picture plane, but any lines that may be at right angles to the principal face, and so to the picture plane, would vanish to the centre of vision. Lines having any other direction would have their vanishing points found in the usual way. As, from rule I, Art. **31**, all lines parallel to the picture plane retain their normal directions in perspective drawing, it follows that *vertical lines have no vanishing point*, and that all lines on the face of a building that are vertical remain vertical. This form of perspective drawing is sometimes spoken of as **parallel perspective**, as though it constituted some distinct class of perspective drawing ; but the principles involved do not differ in any respect from those used in regular perspective. The apparent difference is caused by the exceptional position of the object. In architectural perspective it is generally preferable, for artistic reasons, to arrange the view so that the principal vertical surface is not parallel to the picture plane.

BIRD'S-EYE VIEWS

40. In cases where it is necessary to show the grouping and form of several buildings, a perspective view is drawn with the station point at some considerable distance above the ground, so that the view is that of a person looking at the buildings from a great height. A drawing of this kind is usually spoken of as a **bird's-eye view.** The ordinary methods of perspective drawing are applicable throughout, but, of course, the horizon comes at a distance above the objects depicted and may not be included within the finished drawing.

EXAMPLES OF OBJECTS IN A HORIZONTAL PLANE

41. 45° Set-Square.—In Fig. 13 (*a*) is a plan view of the picture plane in the rear of which is a 45° set-square *a b c* lying on the ground plane, with its apex *a* touching the picture plane and its sides *a b*, *a c* making angles of 45° with the picture plane. The point *a* at the apex of the set-square is immediately in front of the spectator, indicated by the station point *S*. It is, therefore, vertically beneath *O*, the centre of vision. This is not seen in view (*a*), but may be seen in view (*b*). To draw a perspective view of the set-square *a b c*, first find the vanishing points for the sides *a b* and *a c*. For this purpose draw lines from *S* parallel to *a b* and *a c* until they cut the picture plane in V_1 and V_2, which points, according to the rule in Art. **35,** will be the vanishing points for all horizontal lines running at an angle of 45° with the picture plane. Join *S*, *b* and *S*, *c* by lines cutting the picture plane at *b''* and *c''*, respectively. The base *b c* of the set-square is parallel to the picture plane, and will, according to rule I in Art. **31,** be drawn parallel to the horizon in the perspective.

42. To commence the perspective drawing of the set-square, as shown in Fig. 13 (*b*), draw the ground line *A B* at any convenient place on the paper; parallel to it, and at a height above it equal to the height of the spectator's eye above the ground, draw the horizon line $V_1 V_2$. From the point *a* in (*a*), which was stated to be directly beneath the centre of vision,

draw a line perpendicular to $V_1 V_2$, so as to cut the horizon in view (*b*) at *O* and the ground line at *a'*. Then, *O* will be the centre of vision and *a'* will be the point in the perspective view

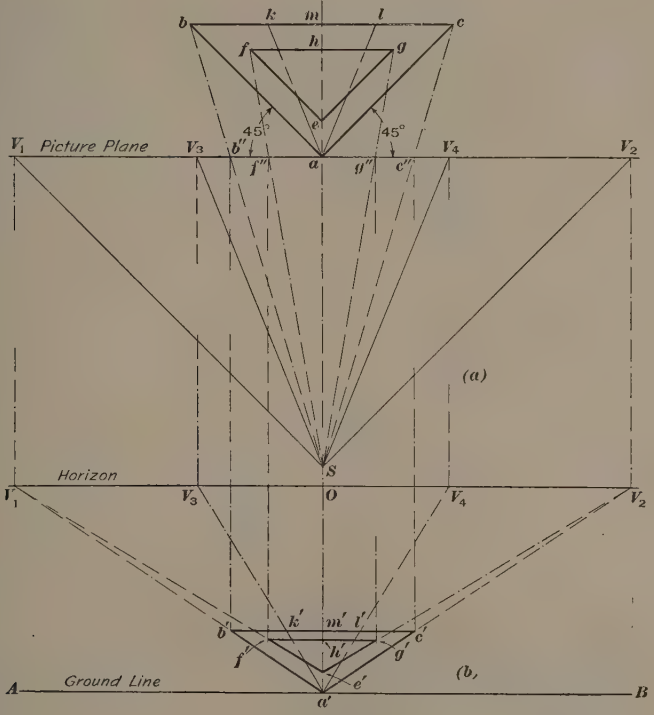


Fig. 13

corresponding to the point *a* in view (*a*). The vanishing points V_1 and V_2 will be on the horizon at distances from *O* at which they were found to be from *a* in view (*a*).

43. From *a'* in Fig. 13 (*b*) draw lines to vanish to V_1 and V_2. Along these lines at some point yet to be determined, the points *b'* and *c'* will be situated. To find these points, draw perpendiculars from *b''* and *c''*, the points in the picture plane where

the projections of points b and c have been found to be, to cut $a' V_1$, $a' V_2$ at b' and c'. Join b' c'. Then, the triangle a' b' c' will be the perspective view of the outside edge of the set-square a b c shown in (a).

44. To prove that this perspective view is correct, and to illustrate the principles, just explained, from a different point of view, a vertical section is shown in Fig. 14, taken at right angles to the picture plane along the line S m in Fig. 13 (a). The letters a e h m in Fig. 14 refer to the same parts as in Fig. 13 (a). From the eye at S, Fig. 14, lines are drawn to a, e, h, m which cut the picture plane at the points a, e'', h'', and m''. These points represent the position on the picture plane of the

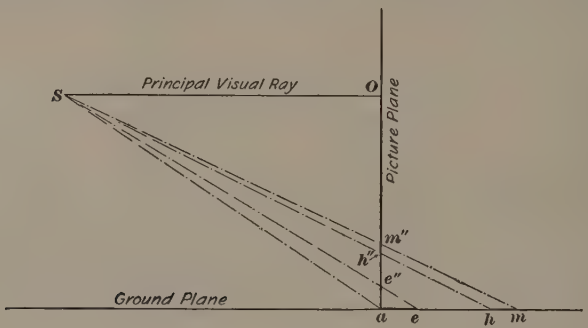


Fig. 14

points a, e, h, m, and give the heights of their projections above the ground line, for the perspective view in Fig. 13 (b). If the distance a m'' in Fig. 14 is the same as a' m' in Fig. 13 (b), then the perspective of the triangle a' b' c' is correct, assuming that Fig. 14 is drawn to the same scale as Fig. 13. On the line a' m' in Fig. 13 (b) set off the distances a' e', e' h', and h' m' equal to the distances a e'', e'' h'', h'' m'' in Fig. 14. Then, two points e' and h' on the inside triangle of the set-square will be found. Draw lines from e' to V_1 and V_2 to intersect a line drawn parallel to b' c' through h' in the points f' and g'. Then, the triangle e' f' g' will be the perspective view of the inner triangle of the set-square. It should be noted that, after fixing the point e' in Fig. 13 (b) and drawing lines from it to V_1 and V_2,

the points f' and g' may also be found by drawing perpendiculars from f'' and g'' in Fig. 13 (a) intersecting $e'\ V_1$ and $e'\ V_2$ at f' and g'. By connecting points e', f', and g' the view will be complete.

45. It will be noticed that in Fig. 13 (a) there are two lines $a\ k$, $a\ l$ drawn across the face of the set-square; it is required to place these lines in the perspective view. As these lines are horizontal, but are not at an angle of 45° with the picture plane, new vanishing points will have to be found for them. So from S

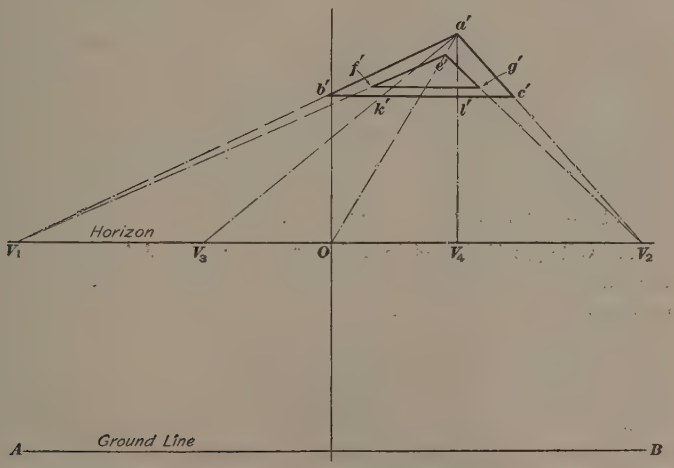


Fig. 15

draw lines parallel to $a\ k$ and $a\ l$ to cut the picture plane in V_3 and V_4, which will be the vanishing points required. Of course, the vanishing points V_3 and V_4 would, according to the rule in Art. **35**, be used for all horizontal lines in the view that are parallel to $a\ k$ and $a\ l$. Project the points V_3 and V_4 from the picture plane in (a) to the horizon in (b), when these will be the vanishing points for the lines $a\ k$, $a\ l$. From a' draw lines to V_3 and V_4. Then, $a'\ k'$ and $a'\ l'$ will be the correct perspective views of the lines $a\ k$ and $a\ l$ in (a).

46. If the set-square of Fig. 13 were drawn in perspective, in any other position to the right or left of the centre of vision, while its sides remained at an angle of 45° with the picture plane, similar sides would vanish to the same points V_1 and V_2 on the horizon. The positions of points V_1 and V_2 will remain unaltered independent of whether the position of the set-square is above or below the horizon. The only requirements are that the sides of the set-square remain at an angle of 45° with the picture plane and that its general surface remains horizontal. In Fig. 15 is shown a perspective view of the set-square with its sides at 45° to the picture plane, and set horizontally above the horizon. The letters refer to the same parts in both illustrations. The constructive details by which the outline of the set-square is found are not shown, as it can be easily followed from the working out of the problem shown in Fig. 13. In the present case the point a' of the set-square is to the right of the centre of vision O and is also above the horizon. After the point a' is placed according to these requirements, the remaining part of the construction is the same as in Fig. 13.

47. Octagon Enclosed in a Square.—In Fig. 16 (*a*) is shown the plan and at (*b*) the perspective view of an octagon *a b c d e f g h* enclosed in a square *i j k l*. If it is required to draw a perspective view of this figure the vanishing points must first be found. The position of the station point has not been shown in Fig. 16 (*a*), but the vanishing points V_1 and V_2 for the lines running at an angle of 45° with the picture plane have been found in a similar manner, as described for Fig. 13. Project the points *i, a, h, l* down to i', a', h', l' on the ground line, as shown, and, as, in accordance with rule II, Art. **31,** horizontal lines at right angles to the picture plane vanish in the centre of vision, join i', O and l', O. These lines will indicate the direction of two sides of the square, but the length of these sides is not known. The diagonals *i k, l j*, which are indicated in the square *i j k l* in (*a*), run at an angle of 45° with the picture plane, and will therefore vanish in V_1 and V_2. In (*b*) draw from i' a line to V_2 cutting $l' O$ at k'. Then, $l' k'$ will be the perspective view of the line *l k* in (*a*), which is one side of the square *i j k l*. In a similar manner draw from l' a line to V_1 cutting $i' O$ at j'. After

joining j' and k' the figure $i'\ j'\ k'\ l'$ will be the correct perspective view of the square enclosing the octagon.

48. The points on the sides of the square where the angles of the octagon coincide with the square must now be found. Two points a' and h' have already been fixed, and their opposite points d' and e' can be found by drawing lines from a' and h' to O cutting $j'\ k'$ at d' and e'. That this construction is correct

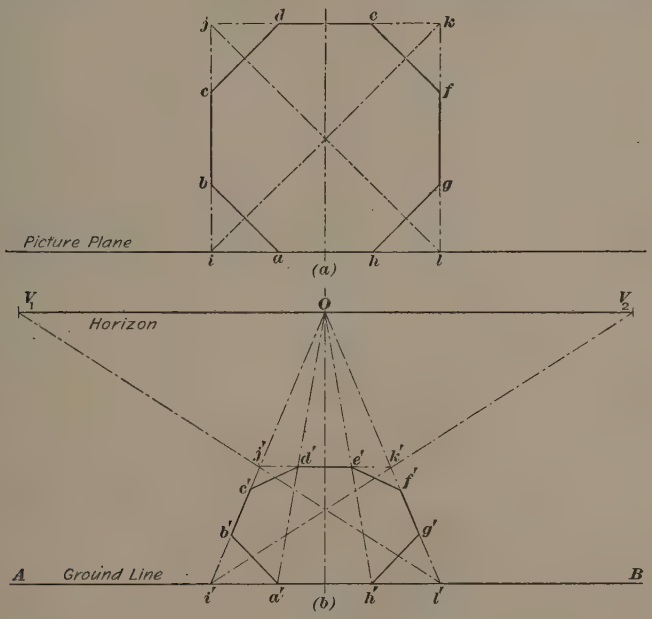


FIG. 16

will be seen from (*a*), where, if a line is drawn through $a\ d$ or $h\ e$, it will be at right angles to the picture plane and parallel with $i\ j$ and $l\ k$. Therefore, lines drawn through $a\ d$ and $h\ e$ will vanish to O. It follows from this that points d' and e' can be found by drawing lines from a' and h' to O cutting $j'\ k'$ in d' and e'. As it is known that all horizontal lines that are at an angle of 45° with the picture plane will vanish to V_1 and V_2, draw from a' and e'

lines vanishing to V_1 cutting $i'\ j'$ in b' and $k'\ l'$ in f'. From d' and h' draw lines vanishing to V_2 and cutting $i'\ j'$ in c' and $k'\ l'$ in g'. Join $a'\ b'$, $d'\ c'$, $e'\ f'$, and $h'\ g'$. The perspective view $a'\ b'\ c'\ d'\ e'\ f'\ g'\ h'$ of the octagon will then be complete.

MEASUREMENT OF VANISHING LINES

49. Measuring Points.—In Fig. 17 (*a*) is shown a plan view of a rectangle *a d e f* on the ground plane, the angle at *a* being in contact with the picture plane and the side *a d* making an angle of 30° with it ; the rectangle is divided into three parts by lines at *b* and *c*. *S* is the station point ; the vanishing points are found by drawing $S\ V_1$ and $S\ V_2$ parallel to *a d* and *a f*, respectively. The perspective at (*b*) is commenced by drawing vanishing lines from a' to V_1 and V_2. The point f', and consequently the line $f'\ e'$, may be obtained by producing *e f* in (*a*) to meet the picture plane in *g* and projecting this point to g' to (*b*). By drawing a vanishing line from g' toward V_1 the direction of the side $f'\ e'$ will be found and also the point f', the latter being the point of intersection between $g'\ V_1$ and $a'\ V_2$. Some method must now be devised for obtaining the length of the divisions *a b*, *b c*, and *c d*. For this purpose mark off on the plan of the picture plane in (*a*) distances *a h*, *h i*, and *i j* equal, respectively, to *a b*, *b c*, and *c d*. On joining *b* and *h*, *c* and *i*, and *d* and *j* the resulting lines will be parallel, so that, when drawn in perspective, they will require only one vanishing point. This may be found by drawing $S\ M_1$ parallel to these lines intersecting the picture plane in M_1.

50. Project the point M_1 to the horizon in (*b*) and project to the ground line points *h*, *i*, and *j*, thus obtaining points h', i', and j'. From h', i', and j' draw vanishing lines to M_1, cutting $a'\ V_1$ in b', c', and d' ; then, $h'\ b'$, $i'\ c'$, and $j'\ d'$ are correct perspective representations of *h b*, *i c*, and *j d*. The points b', c', d' have therefore been correctly determined. The drawing may now be completed by drawing vanishing lines from d', c', and b' toward V_2 to cut the line $f'\ V_1$. The parts of these lines that are intercepted by the perspective figure, such as $d'\ e'$, are the required lines. It should be observed that by

means of the point M_1 it is possible to obtain the correct perspective lengths of lines vanishing to V_1 by marking off their actual lengths on the ground line. Vanishing lines drawn from these marks to M_1 intersect the line vanishing to V_1, and so cut off

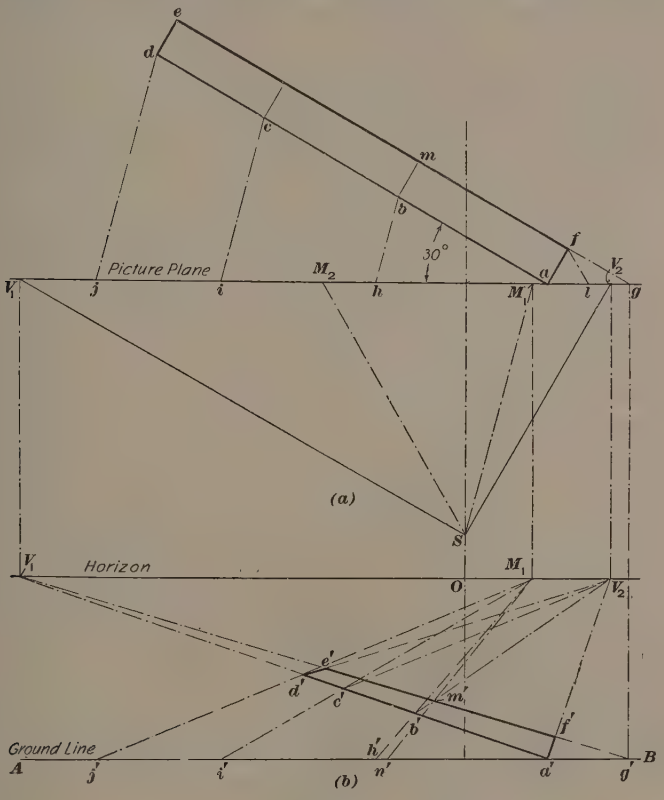


Fig. 17

the proper lengths on it. Points such as M_1 are known as **measuring points.**

51. If it had been necessary to mark off divisions along $a'f'$, a measuring point could have been found in exactly the same

way as M_1 was found; that is, $a\,l$ would be made equal to $a\,f$ and $S\,M_2$ would be drawn parallel to $f\,l$. The point M_2 would then be the measuring point for all lines vanishing to V_2. By considering this illustration and the method of its construction, it is evident that in the triangle $a\,d\,j$ the side $a\,d$ is equal to $a\,j$. As the sides in the triangle $M_1\,V_1\,S$ are parallel to those in triangle $a\,d\,j$, it follows that the distance $V_1\,M_1$ is equal to $V_1\,S$. For similar reasons the distance $V_2\,M_2$ is equal to $V_2\,S$. *The measuring point corresponding to any particular vanishing point may therefore be obtained by setting off from the vanishing point, in question, on the side toward the centre of vision a distance equal to the distance of the vanishing point from the station point.* The measuring point so found may be used in connection with all lines that vanish toward this particular vanishing point.

52. A word of caution is necessary as to the position on the ground line where the lengths shall be set off. In Fig. 17 they are set off from a', which represents the point a where the line $a\,d$ meets the ground line. Should the line, on which a given length is to be set off, not intersect the ground line, then it must be produced until it meets both the plan of the picture plane and the ground line. For instance, if it were desired to find the perspective of point m, the length $g\,m$ must be set off in view (b) as $g'\,n'$ from g', which represents the point g where the line $e\,f$ meets the picture plane. From n' draw a line towards M_1 cutting $e'\,f'$ in m', which is the point required.

53. Method of Projectors on Plan. — Another method of placing in perspective the figure of Fig. 17 is shown in Fig. 18. In this method no measuring points are used. As before, the plan is given at (a), and the vanishing points are obtained in the manner explained by means of the preceding example. Lines are drawn from every necessary point of the figure $a\,d\,e\,f$ to the station point, giving by their intersection with the picture plane the plans of their projections, as b'', c'', d''. In drawing the perspective at (b), these points are projected vertically downwards, so as to intersect the vanishing lines through a' and give the points d', c', and b'. The point f' may be obtained by drawing a vertical line from f'' cutting the line $a'\,V_2$ at f';

but as these lines intersect at a very acute angle, the point of intersection cannot be very accurately determined in this manner. A slight inaccuracy in the drawing would give a very inaccurate

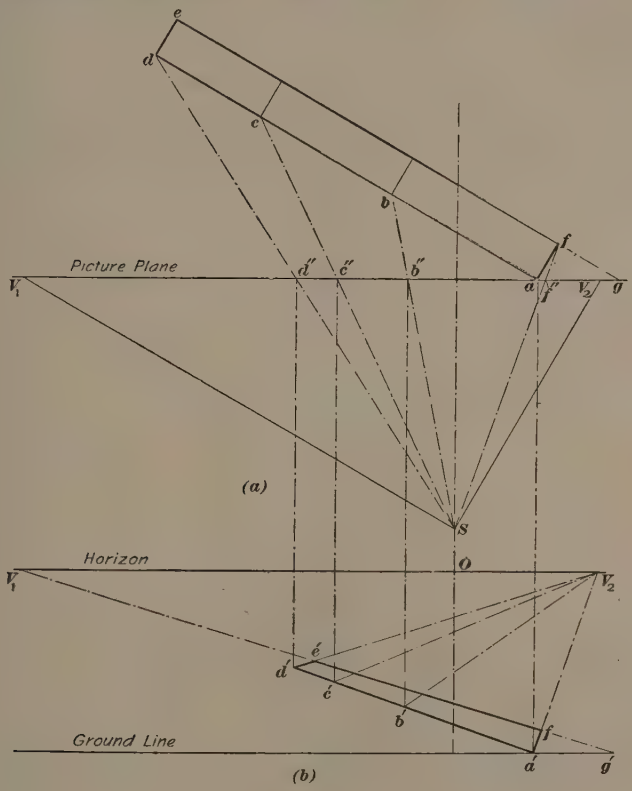


Fig. 18

perspective. In this case it is therefore better to produce ef to g and proceed as in the last example.

This method of finding the proper lengths of vanishing lines by means of projectors is practically the one used in Fig. 13 to obtain the lengths of the vanishing sides of the set-square,

and is the method almost exclusively used in architectural perspectives; but it is advisable to be familiar with both methods, as special cases may require the use of measuring points. By comparing Fig. 17 (*b*) and Fig. 18 (*b*), it will be seen that the results are the same.

APPLICATION OF PERSPECTIVE PROJECTION

54. Plan of House.—In Fig. 19 is shown the plan of a small house which it is required to show in perspective. The front

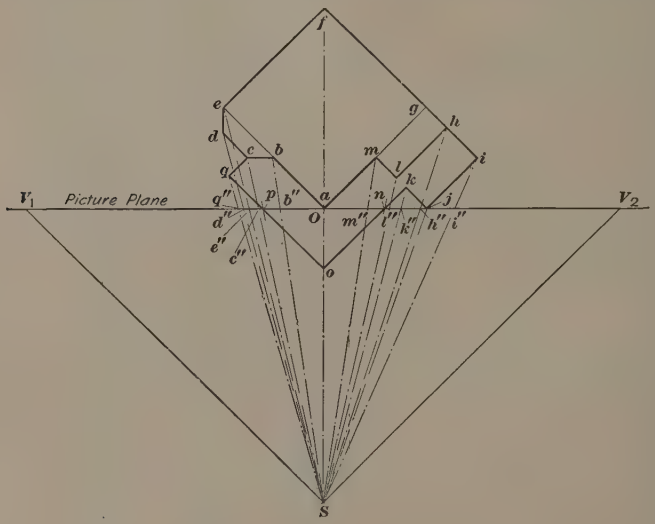


FIG. 19

sides make angles of 45° with the picture plane, and the point *a* of the plan is in contact with the picture plane immediately below the centre of vision. To obtain the positions of the projections of the various points on the plan of the picture plane, projectors are drawn from each point, as *d*, *c*, etc., to the eye, giving the positions of the points of projection by their intersection with the plane, as at *d''*, *c''*. The vanishing points are found at V_1 and V_2, as previously explained.

55. The perspective of the house plan is shown in Fig. 20. It is begun by drawing the ground line, adding the horizon at a distance above the ground line equal to the height of the eye above the ground line. After fixing the centre of vision O, the vanishing points V_1 and V_2 are set off at both sides of point O at the distances indicated in Fig. 19. A perpendicular is now drawn from O to the ground line; the point of intersection gives the position of the point a', which is the projection of a. Vanishing lines are now drawn from point a' to V_1 and V_2. After marking off along the ground line $A\,B$ the points b'', c'', etc., the perspective of these points may be found by drawing verticals from their projections on $A\,B$ so as to intersect the

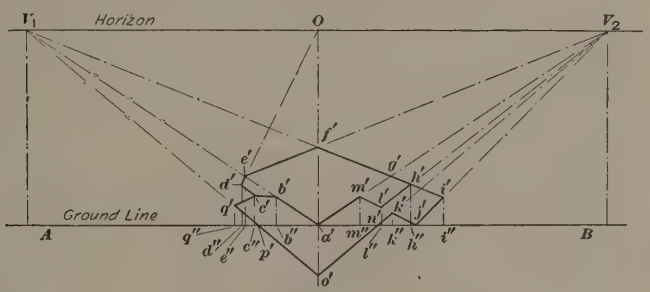


Fig. 20

vanishing lines on which they are situated. This method corresponds to that employed for Fig. 13.

56. Beginning with point e', its position is fixed by finding the point of intersection between the vertical from e'' and the vanishing line $a'\,V_1$. A vanishing line from e' to V_2 gives the position of the side $e'\,f'$, and its point of intersection with $a'\,O$ fixes the point f'. That points f' and a' must lie on a line that vanishes to O is evident from the fact that S, a, and f in Fig. 19 are points on a line at right angles to the picture plane. They must therefore be on the same vanishing line in Fig. 20, and on one that passes through the centre of vision. A vertical from m'' intersecting $a'\,V_2$ fixes the point m'. Through m' a line is drawn vanishing to V_1 to fix by its intersection with verticals

through l'' and k'' the points l' and k'. This line should also meet the ground line at j'; if not, the construction has not been quite accurate. Through l' a line is drawn vanishing toward V_2 to fix h' by its intersection with a vertical through h''; and through j' draw a vanishing line to V_2 to find i' in a similar manner. A line drawn from i' toward V_1 should pass through h' and meet a' O in the point f'. It is evident that some of the points may be found in a different manner and still give correct results. For instance, the point i' may also be found by producing the line V_1 f' until it meets the line j' V_2, thus fixing the point i'.

57. To fix the projection of the bay window e d c b, the point b' may be found by drawing a vertical through b'' to intersect a' e'; then, since b c is parallel to the picture plane, b' c' will be horizontal, and the point c' may be determined by drawing a vertical through c'' to meet the horizontal through b'. The side c' d' must vanish toward V_1 and d' will be on the vertical through d''. The line d' e' representing the side d e, which is at right angles to the picture plane, must vanish toward O. The correct position of this line will also test the accuracy of the drawing. To find q', draw a line through c' vanishing to V_2, intersecting the vertical through q'' in q'. The point o' may be found by drawing the vanishing lines V_1 q' and V_2 k', their point of intersection giving the point o', which should fall on the line O a' produced. This completes the perspective of the ground-plan outline of the house. Verticals through the various angles would represent the corners of the building; but as yet no suitable means have been indicated by which to determine the perspective lengths of vertical lines.

MEASURING VERTICAL LINES

58. In Fig. 21 four vertical rods a, b, c, and d are shown at (a) in plan and at (b) in elevation. It is seen that they are all of equal height and have subdivisions similarly placed, so that the lines joining corresponding divisions of the rods will be horizontal. If it is desired to show these rods or scales in perspective, scale a is set up and its actual height and several

divisions marked off, because it is in contact with the picture plane. As scales *b*, *c*, or *d* are back from the picture plane, some means must be found for ascertaining the proper height of their divisions. Considering scales *a* and *b*, it is clear that the lines

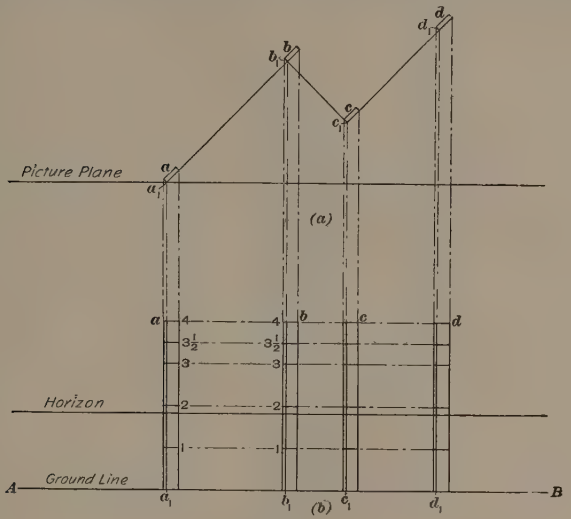


FIG. 21

connecting all the divisions marked *1* must be horizontal, and will therefore in the perspective view vanish to one common vanishing point. The same remark applies to the lines connecting other divisions similarly marked.

59. This vanishing point may be found, as shown in Fig. 22 (*a*), by drawing through the station point *S* a line parallel to the line $a_1 b_1$, intersecting the picture plane at V_2.

The perspective view, Fig. 22, is begun by drawing on a ground line a vertical $a_1 a$ representing the edge a_1, which is situated in the picture plane. On this line are set off the divisions, as given on rod *a* in Fig. 21 (*b*), and vanishing lines are drawn from the subdivisions to V_2. It is evident that any vertical erected on the line $a_1 V_2$ will, by means of the vanishing lines, be divided into smaller parts between which there will be the same ratio as

there is between those on rod $a_1\,a$. If, therefore, the base of rod b is drawn in perspective by the method employed in Fig. 20, and verticals are erected on this base, the positions of the various subdivisions will at once be indicated by the points of inter-

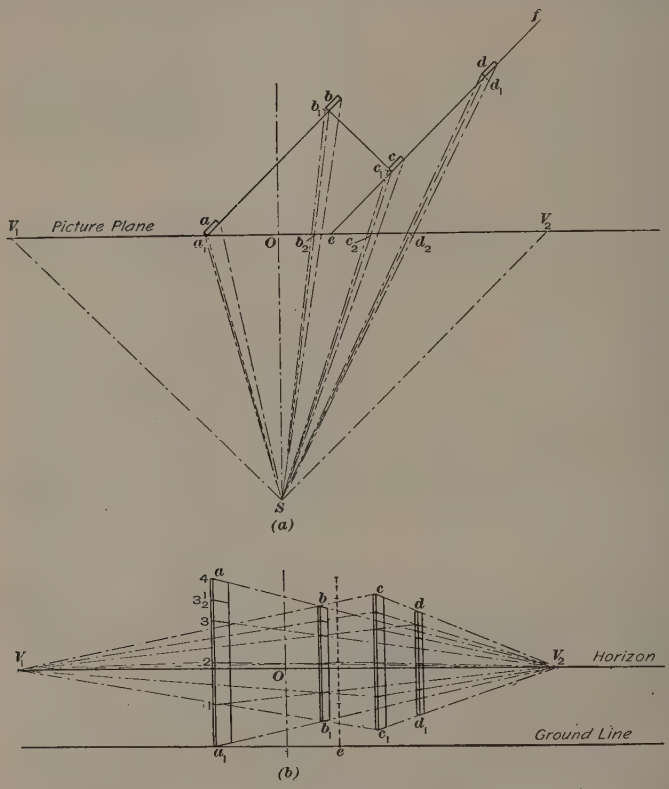


Fig. 22

section with the various vanishing lines passing to V_2, as shown in Fig. 22.

60. The divisions on scale c in the perspective cannot obviously be obtained by the intersection with $c\,c_1$ of the lines vanishing from the divisions of $a_1\,a$ to V_2, because if a line is

drawn connecting a_1 and c_1 in the plan, Fig. 22 (*a*), it will not be parallel to $S\ V_2$, so that V_2 is not the correct vanishing point for such lines, if their heights are taken from $a_1\ a$. The divisions of scale c may be found in one of two ways. One would be to draw in Fig. 22 (*a*) a line from c_1 parallel to $a_1\ b_1$ to meet the picture plane in e, and then erect a line at e in view (*b*), similar in all respects to $a\ a_1$. Vanishing lines are then drawn to V_2 subdividing rod $c\ c_1$ in the correct manner. Such a line as the vertical at e is called a **height line,** that is, a line in the picture plane such that its vertical divisions are set off to the same scale as that used in the vertical projection of the object or objects of which it forms a part. This measuring line can be used as such only for lines that are situated in a vertical plane parallel with the line joining the station point and the vanishing point to be used. For instance, if in Fig. 22 (*a*) a vertical plane is placed on the line $e\ f$, and this line is parallel to $S\ V_2$, then any vertical line situated in this vertical plane will be divided proportional to the height line at e by vanishing lines drawn from points on this height line.

61. Another method for dividing the line $c\ c_1$ is to transfer to it the division effected on line $b\ b_1$. For this purpose it is necessary to find the vanishing point for the line $b_1 c_1$, Fig. 22 (*a*), by drawing the line $S\ V_1$ parallel to it. The point V_1 is then the vanishing point, which is transferred to Fig. 22 (*b*) as shown. If, now, vanishing lines are drawn from V_1 through the divisions on $b\ b_1$ so as to intersect line $c\ c_1$, the point of intersection will indicate the correct positions of the division points on the line $c\ c_1$. As line $c_1\ d_1$ is parallel to $S\ V_2$, vanishing lines may be drawn from the division points on $c\ c_1$ to point V_2; then the points at which these lines intersect line $d\ d_1$ will be the required division points on $d\ d_1$.

PERSPECTIVE OF INCLINED PLANES

62. Gabled House.—In Fig. 23 is shown an object resembling a four-gabled house, view (*a*) being a plan and (*b*) an elevation. To draw a perspective of the object, if S, Fig. 24 (*a*), is the station point, the vanishing points V_1 and V_2 are found in the

manner previously explained; and the positions of the projections of the various points of the object are determined on the picture plane in (*a*). In view (*b*) the horizon is drawn to a convenient scale at the desired height above the ground line. Then the points d_2, c_2, etc., in Fig. 24 (*a*), are set out on the

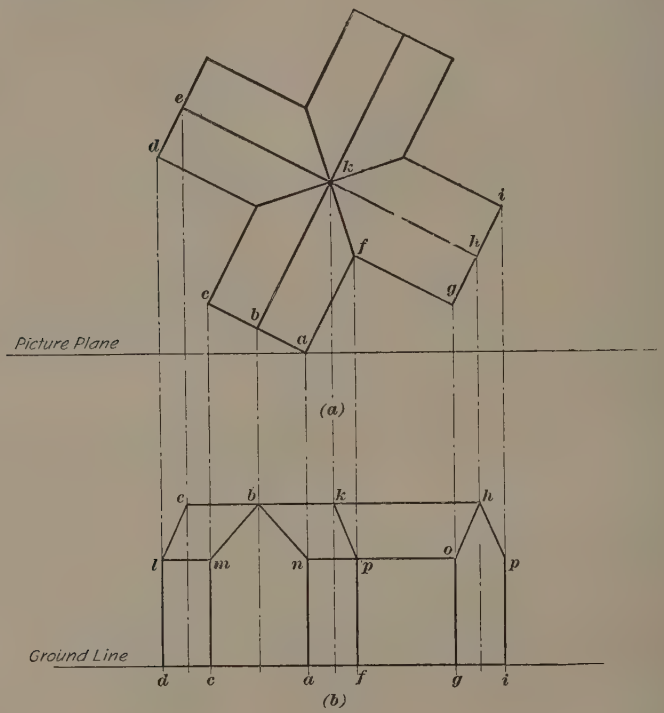
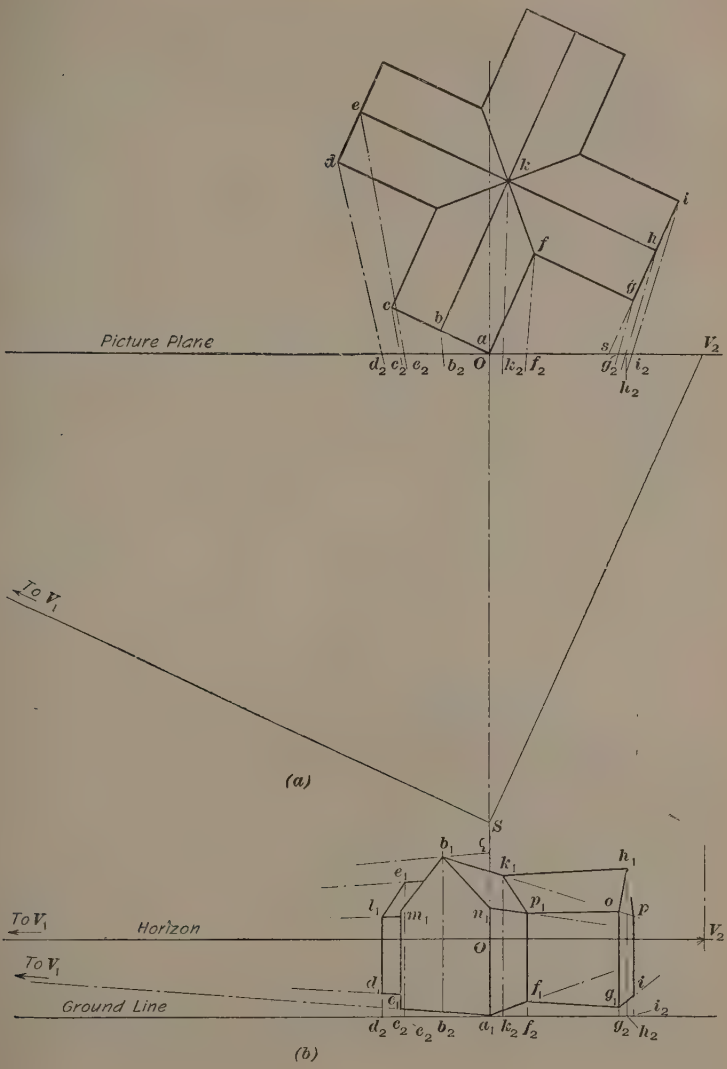


Fig. 23

ground line. To proceed with the perspective, a line is drawn from a_1 vanishing toward V_1 to meet the vertical from c_2, thus fixing the point c_1. At a_1 and c_1 erect verticals, and, since a_1 is in the picture plane, $a_1 n_1$ in Fig. 24 is made the full height of $a\,n$ in Fig. 23 (*b*), and m_1 is found at the point where the vanishing line $n_1 V_1$ intersects the vertical through c_1.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d
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Picture Plane
V2
d2 c2 e2 b2 O k2 f2 g2 i2
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(a)
S
b1
k1
h1
e1
l1
m1
n1
p1
o
p
To V1
Horizon
V2
O
To V1
d1
c1
f1
g1
i
i2
Ground Line
d2 c2 e2 b2 a1 k2 f2 g2 h2
(b)

FIG. 24

63. To ascertain the position of b_1, erect a vertical through b_2, but as this line is not on the picture plane a height line is necessary from which to obtain the height of b_1. As the vertical $a_1 n_1$, representing $a n$, is on the picture plane and the line $a b$ on plan vanishes to V_1, $a_1 n_1$ may be used as a height line in conjunction with the vanishing point V_1. Set up $a_1 q$ equal to the height of b above the ground line in Fig. 23 (b) and draw a vanishing line from q toward V_1 to fix b_1 by intersection with the vertical from b_2. Join $b_1 n_1$ and $b_1 m_1$, thus completing the front gable. To draw the side, draw a vanishing line from a_1 toward V_2 to meet the vertical through f_2 in f_1; continue the vertical from f_1 to meet in p_1 a line from n_1 toward V_2. The point k_1 may best be found by a vanishing line from b_1 toward V_2, intersecting a vertical through k_2. The heights of the right-hand gable may be fixed by means of a height line, found at s in Fig. 24 (a), and a vanishing line to V_2; but in this case they may more readily be found by vanishing lines drawn through k_1, p_1, and f_1 from V_1 to meet verticals through h_2 and g_2, giving points h_1, o, and g_1. The points i and p may be found by vanishing lines from g_1 and o toward V_2 to meet a vertical through i_2. By joining $h_1 p$ and $h_1 o$ the right-hand gable is complete.

64. The left-hand gable $d e$ could be set off from another height line, but it will be noticed that the horizontal lines of this part of the building are merely the lines of the right-hand gable produced; so that points d_1 and l_1 are best determined by continuing $g_1 f_1$ and $o p_1$ toward V_1 to meet the vertical through d_2. Point e_1 may similarly be found by producing $h_1 k_1$ to meet the vertical through e_2, the latter point being found by drawing a radial projector from the corresponding point e in view (a) cutting the picture plane at e_2. Then the line joining $e_1 l_1$ completes the drawing.

Vanishing points for systems of parallel lines in oblique planes, such as $l_1 e_1$ and $o h_1$ in Fig. 24, may be found, but they are seldom used in architectural perspective, the usual method of finding the ridge and gable lines of roofs being as indicated in the description of Fig. 24.

CURVES IN PERSPECTIVE

65. It is necessary at this point to explain the methods adopted in drawing a curve in perspective, and then any problem that may be met with in architectural drawing should present no difficulty in its solution, for all architectural perspective is based upon the principles already described.

66. Perspective of an Arch.—In Fig. 25 (*a*) is shown an elevation, and at (*b*) a plan, of an arch ; the right-hand half of the arch has the voussoirs shown, and the points where these voussoir joints cut the soffit line of the arch are projected down to the plan. The elevation shows only the arch itself, and not the lower part of the opening with the ground line. Only half the elevation is drawn complete, but the plan has to be fully detailed on account of the projectors being drawn to the station point. At (*b*) the arch is shown in sectional plan, the section being taken along the horizon line, but the voussoir joints are, for clearness' sake, shown in dotted lines. The picture plane forms an angle with the front side of the arch, as shown. The projectors from each point to the station point are indicated, but the station point itself cannot be shown in the figure, as it is outside the limits of the paper. The vanishing points are also too far away to be included in the illustration; but they are found in the usual way, V_1 being the left-hand point and V_2 the right-hand one, situated in the direction indicated.

67. The perspective is shown in Fig. 26. The horizon and the centre of vision are shown, but the vanishing points are again beyond the figure, though of course they are necessary for the work, and have been found and used in preparing the drawing. The method adopted in putting a curve, such as this, in perspective is to find the true perspective position of several points on the curve and draw a line through them. In this case the joints of the voussoirs where they intersect the edges of the soffit will serve the purpose. The explanation will serve to show how one of these voussoirs has been drawn, and the treatment will be similar for the other voussoirs. The point H where the face of the wall intersects the picture plane will serve

as a height line in conjunction with the vanishing point V_2; as

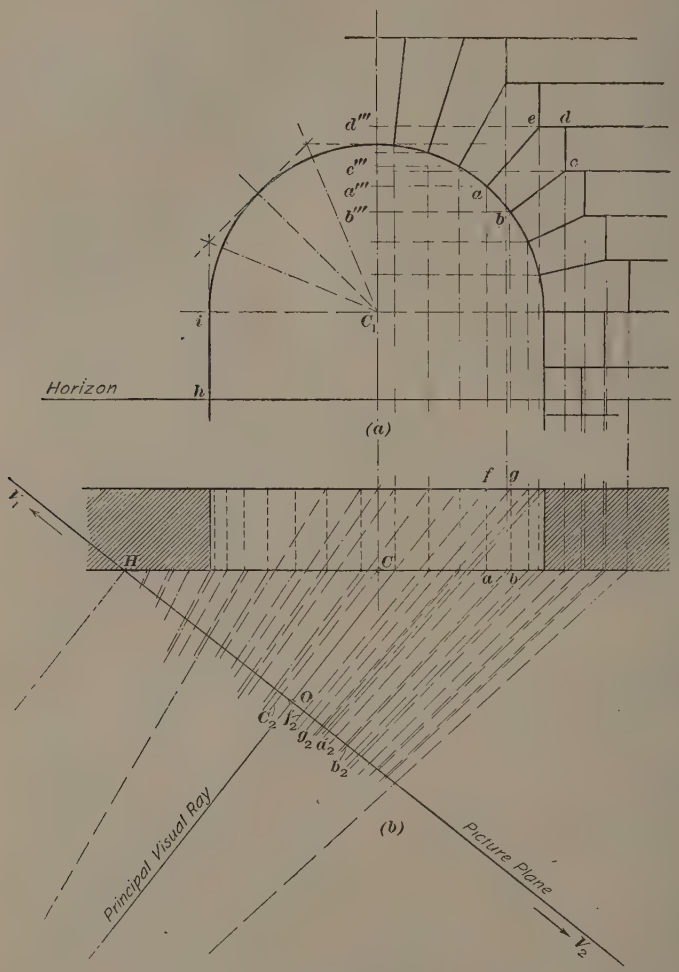


Fig. 25

the ground line is not shown, all heights are measured above the horizon, or eye level.

68. The springing line of the arch is first found by setting off, in Fig. 26, $h_1 i_1$, equal to $h i$ in Fig. 25 (a), on the height line, after which vanishing lines are drawn from i_1 toward V_2; the position of C_1, the centre of the arch, is found by measuring the distance between C_2 and O on the plan, and setting it off on the horizon to the left of O, then verticals are drawn upwards to cut the springing line in C_1. Considering the voussoir $a\,b\,c\,d\,e$ in the elevation, Fig. 25 (a), the points a, b appear in the plan at (b) and the position of their projections on the picture plane at a_2 and b_2.

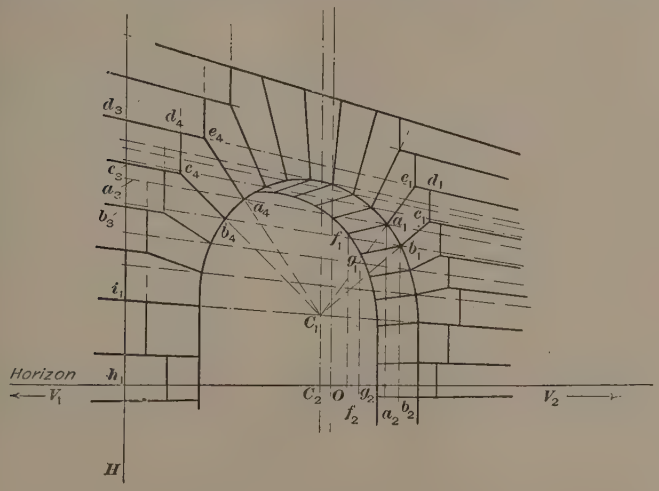


Fig. 26

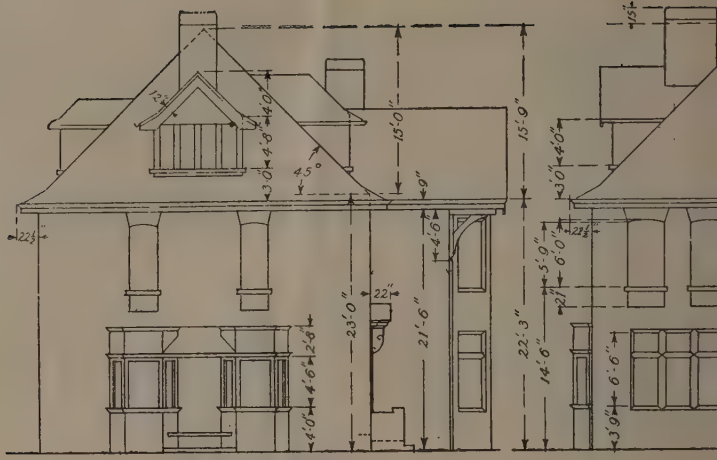
Mark off a_2 and b_2 on the horizon line in their correct positions in Fig. 26 and draw verticals through them. On the height line H set up $h_1 a_3$ and $h_1 b_3$ equal to the height of a and b above the horizon and draw vanishing lines from each point toward V_2. The intersection of the vanishing line from a_3 with the vertical from a_2 will give the position of a_1, and the intersection of the vanishing line from b_3 with the vertical from b_2 will give b_1. The points f_1 and g_1 may be found by drawing vanishing lines from a_1 and b_1 toward V_1 intersecting verticals from f_2 and g_2.

69. In the elevation all the joints between voussoirs radiate from the centre of the arch, and consequently the perspectives of all the joints between voussoirs will radiate from the centre, at C_1 in Fig. 26. Therefore, the direction of $a_1 e_1$ and $b_1 c_1$ may be found by drawing lines from the centre C_1 through a_1 and b_1. To find points e_1, d_1, and c_1, set off on H, the height line, $h_1 c_3$ and $h_1 d_3$, the correct heights of c_1 and d_1 above the horizon line, and draw vanishing lines from these points toward V_2 intersecting the lines $C_1 a_1$ and $C_1 b_1$, both produced, thus fixing points e_1, d_1, and c_1. The perspective representation of voussoir $a_1 b_1 c_1 d_1 e_1$ is now complete, and the other voussoirs are drawn in the same manner. The drawing of the corresponding voussoir on the other side, that is, $a_4 b_4 c_4 d_4 e_4$ in Fig. 26, would be made at the same time as that of $a_1 b_1 c_1 d_1 e_1$, because all vanishing lines from the height line H apply equally to it. All such points as b_1, a_1, a_4, b_4 are points on the near edge of the arch, and a curve drawn through them will give the front arch line in perspective. A curve drawn through all such points as f_1, g_1 on the rear side gives the other outline of the arch.

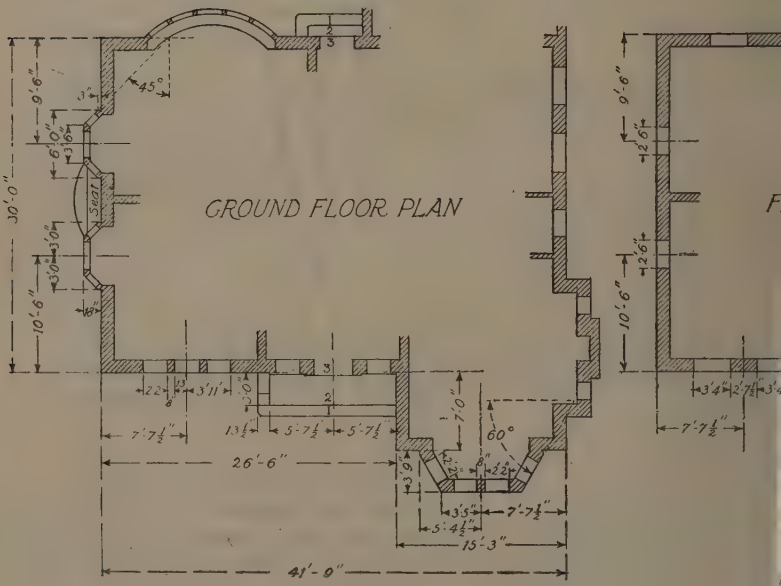
70. In the case of a curve, whether in a vertical, horizontal, or oblique plane, having no marked points on it that may be put in perspective, such points are taken on the curve that may conveniently be found in perspective; a line drawn through them will give the desired curve. In Fig. 25 (*a*), the left-hand half of the arch is shown enclosed by a quarter octagon, which could easily be shown in perspective and the curve drawn within it tangential to the sides. A little thought and ingenuity will often save a great deal of labour in the application of this principle, the object being to obtain several points on the projection of the given curve by a method which, with a minimum of labour, combines sufficient accuracy in the results.

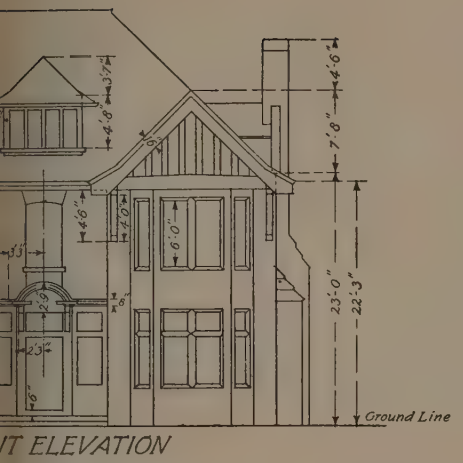
PERSPECTIVE DRAWING OF A HOUSE

71. Preliminary Considerations.—In Fig. 27 is shown the front and side elevations of the house shown in *Architectural Drawing*. The plans of the front walls of these elevations, at the ground floor, first floor, and roof level, are also shown, with



SIDE ELEVATION





IT ELEVATION

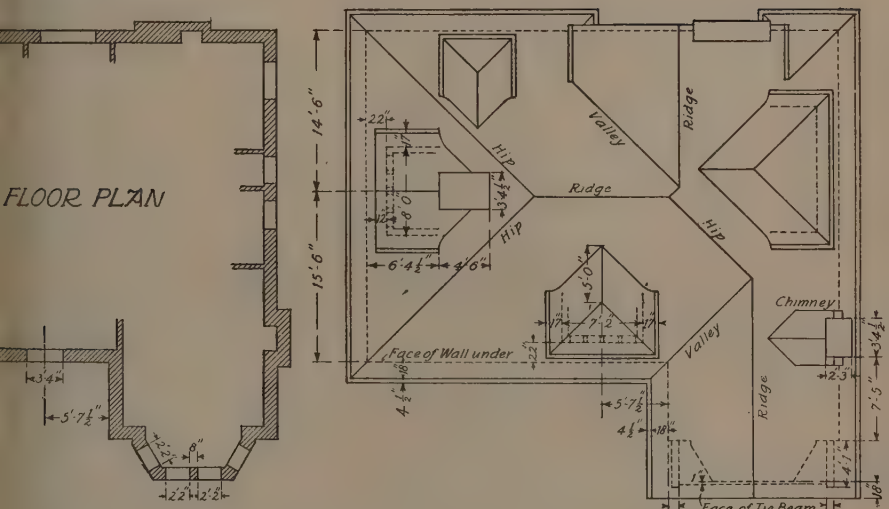
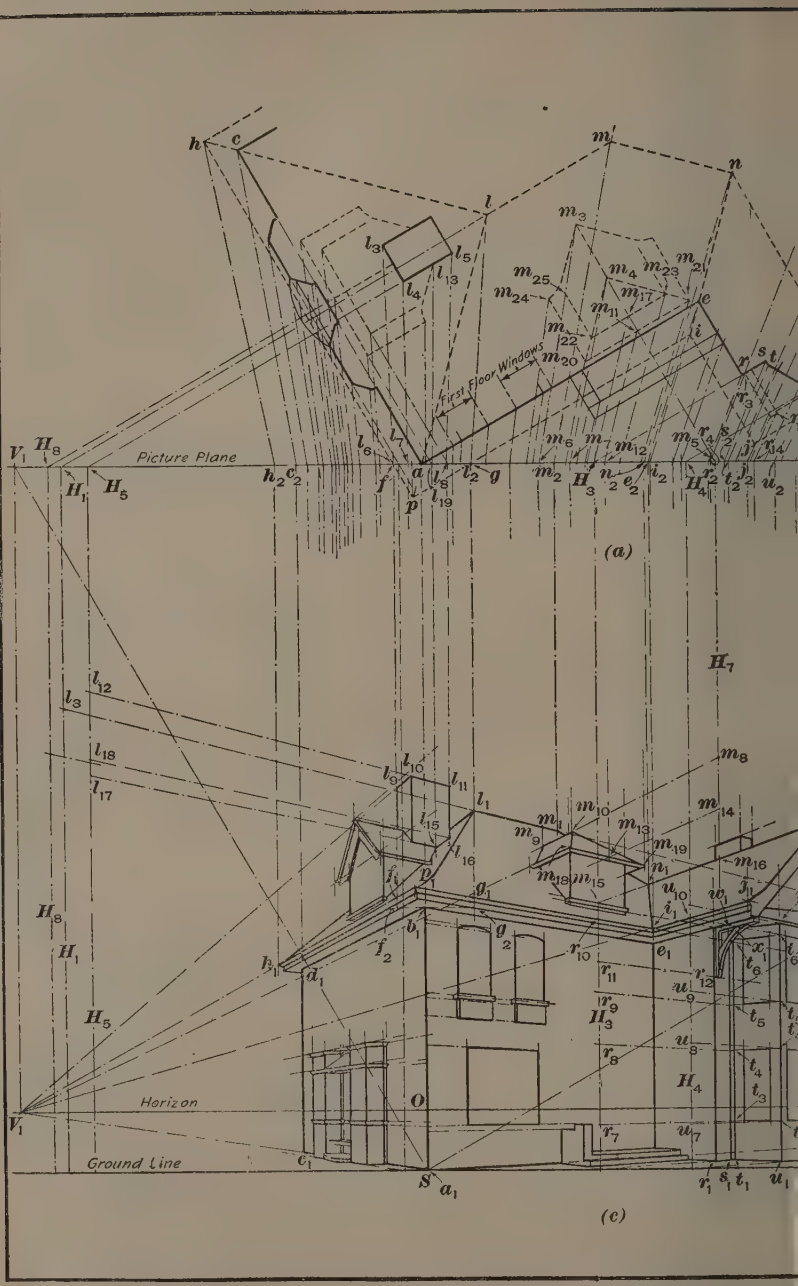
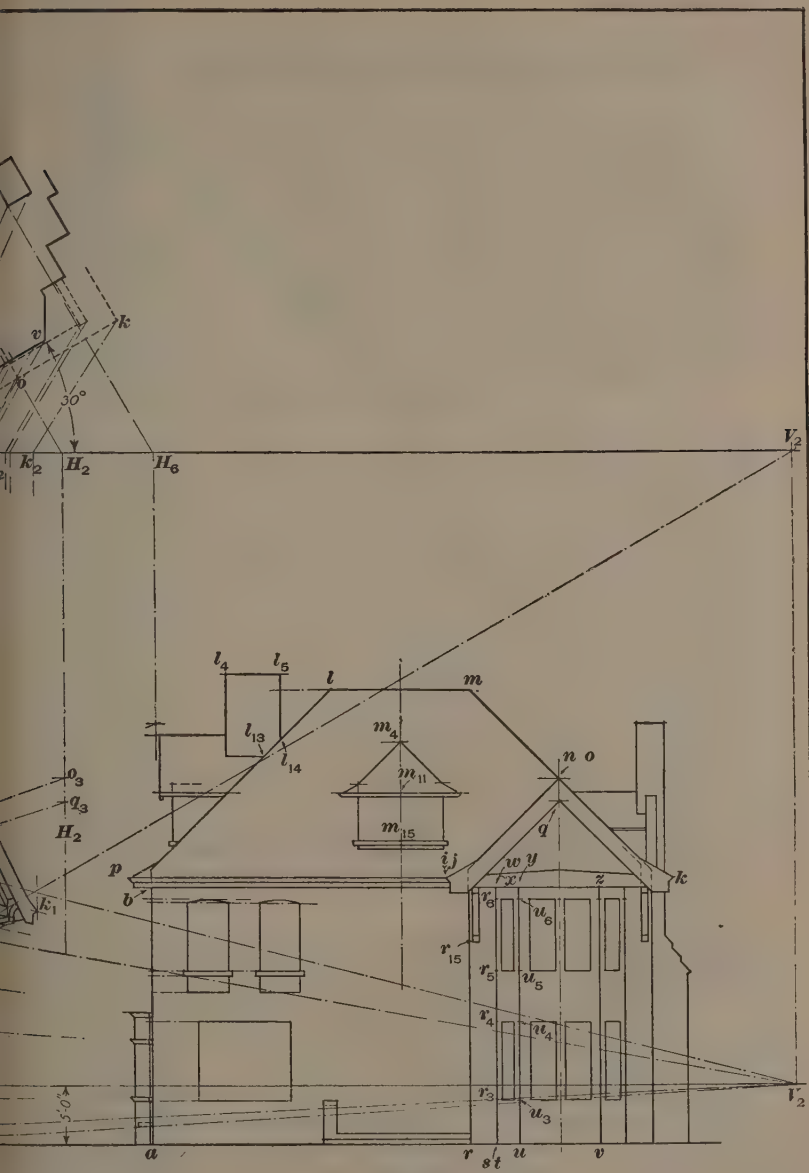


FIG. 27


Picture Plane
First Floor Windows
(a)
Horizon
Ground Line
(c)


v
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m_{15}
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H_2
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i j
w y
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r_8
u_6
r_{15}
r_5
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r_4
u_4
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(b)

sufficient detail in each to enable a perspective drawing to be made from them. In practice, the information given to a draughtsman intending to draw a perspective would probably be a complete set of the architect's working drawings, from which he would select the needed particulars, finally copying, perhaps on tracing paper, the details shown on the plans in Fig. 27. If the building is large and complicated, or shows much variation between the various floor plans, the plans are sometimes traced over one another in different coloured inks, so that when points have to be found on the picture plane, the various plans can be easily distinguished.

72. For a building of the kind shown in Fig. 27, a simple pencil tracing taken from the working drawings, giving the amount of detail shown in the plans in Fig. 27, will be all that is required. On this tracing of the plan, the station point must be fixed in relation both to the building and the picture plane. On referring to Fig. 28, it will be seen that the picture plane has been fixed so that the front wall makes an angle of 30° with the picture plane. Having fixed on the tracing the position of the picture plane, the station point S must be chosen; in this case it has been placed on a line $a\,a_1$ which is at right angles to the picture plane. The distance between S and the picture plane is 59 feet. It is noticed that in Fig. 28, in order to facilitate the drawing and to save space, the perspective is drawn on the plan Fig. 28 (*a*), the corner a_1 of the building coinciding with the station point S, but it must be clearly understood that the point a_1 may be placed in any convenient position above or below point S.

73. Lines must now be drawn from every important point of the plan toward the station point S, cutting the picture plane in the various points shown in Fig. 28 (*a*). For instance, the line drawn from h cuts the picture plane at h_2, that from e at e_2, and so on. The vanishing points are found by drawing from S lines parallel to the sides of the building intersecting the picture plane in the points V_1 and V_2. This will complete the preliminary work upon the plan. In Fig. 28 (*a*) the plan of the building is redrawn above the picture plane, but in practice the

usual method adopted is to cut across the tracing of the plan just below the line indicating the picture plane, and then pin it on the drawing-board over the paper on which the perspective is to be drawn, taking care that the line representing the picture plane is horizontal.

74. Let it be imagined that the tracing has been placed in its correct position on the drawing-board as at (*a*), Fig. 28. The perspective shown in (*c*) can now be commenced. First draw the ground line parallel to the picture plane in (*a*); then, at a height of 5 feet above it, to a scale of $\frac{1}{8}'' = 1'$, draw the horizon line parallel to the ground line. If the drawing-board is large enough, and it is always more convenient to work with a large board when drawing perspectives, the side and front elevations can be traced and pinned at the side of the perspective view, or else can be drawn on the paper at the side, as shown. Care must be taken, however, that the ground line of the elevations coincides with the ground line already drawn for the perspective. In Fig. 28 it will be seen that the front elevation only has been placed in this position, at (*b*), owing to want of space. The reason for placing the elevations in this position is that the various heights may be transferred simply by means of the T square from the elevations to the various height lines in the perspective, thus saving time in measuring each height separately from the elevations. Project the points V_1 and V_2 from view (*a*) to the horizon in (*c*); then these points will be the vanishing points for the perspective view.

75. Finding Positions of Main Wall Lines and Roof.—Project the point *a* in (*a*) to the ground line at a_1 in (*c*); as the line *a b* in (*b*) is on the picture plane, $a_1 b_1$ in (*c*) is made the full height of *a b* in (*b*), and is the perspective projection of the near angle of the building. As the corner $a_1 b_1$ is in contact with the picture plane, the line $a_1 b_1$ will serve as a height line on which to measure the heights above the ground of the various horizontal lines on the two faces of the building that meet in *a b*. Now draw through c_2 in (*a*) a vertical of indefinite length toward (*c*), and from a_1 and b_1 vanishing lines toward V_1 cutting this vertical in the points c_1 and d_1; then $c_1 d_1$ will be the correct perspective

projection of the vertical edge of the building shown in plan at *c* in (*a*), but is not seen in (*b*), though it corresponds in height to the line *a b*. The perspective outline $a_1\ c_1\ d_1\ b_1$ of one side of the house has now been found. The point e_1 may be found by drawing a vanishing line from b_1 to V_2 cutting a projector from e_2 in (*a*) at the point e_1.

76. It is now necessary to find the projection of the eaves of the roof, and, as will be seen from (*a*), the outer edge of the eaves gutter is shown on plan by the dotted line *h f p g i j k*. This dotted line cuts the picture plane at the points *f* and *g*, and these points, when projected to (*c*), can therefore be used for height lines. Draw projectors from *f* and *g* in (*a*) towards (*c*), and by means of the **T** square project to (*c*) the lines representing the top and under side of the eaves gutter in (*b*) to intersect the projectors at the points f_1, f_2 and g_1, g_2. Through the points f_1 and f_2 draw vanishing lines to V_1 to meet a vertical from h_2 in (*a*) at h_1, which will be the extreme end of the gutter. Through g_1 and g_2 draw vanishing lines to V_2 indefinitely in both directions, and produce the line $h_1 f_1$ to meet this line at the point p_1, which will be the correct projection of the corner *p* of the gutter in (*a*). Produce $p_1 g_1$ toward V_2 until it is cut by the vertical projector from i_2 in (*a*) at the point i_1. Then i_1 is the perspective of the point *i* in (*a*). Through i_1 draw a vanishing line to V_1 until the line is cut by a projector from j_2 in (*a*) at j_1. Then, from j_1, draw a vanishing line to V_2 so as to cut the vertical projector from k_2 in (*a*) at the point k_1. The upper line of the gutter $h_1\ p_1\ i_1\ j_1\ k_1$ is now complete, and the under side of it may be found in a similar manner, although in practice it is often sketched in, long experience teaching the draughtsman how to do this with accuracy.

77. It will now be necessary to indicate the outline of the roof, the first line required being the ridge line *l m* in (*a*). These two points are projected on to the picture plane at l_2, m_2, from where projectors must be drawn toward (*c*). As neither point is situated in the picture plane a separate height line must be found so as to determine their correct place in (*c*). In (*a*) produce *l m* to cut the picture plane in the point H_1, from where

a projector is drawn to (*c*), as shown. From (*b*) by means of the **T** square project the point *l* to l_3 in the line H_1, and from this point draw a vanishing line to V_2 cutting the lines projected from l_2 and m_2 at l_1 and m_1. Then $l_1 m_1$ is the perspective of the ridge. The ridge $n_1 o_1$ may be obtained in a similar manner by means of the height line H_2 and a vanishing line from point V_1. The height line H_2 is obtained by producing *n o* in (*a*) to cut the picture plane at H_2, from where a projector is drawn to (*c*). By joining m_1 and n_1 in (*c*) the hip *m n* in (*a*) is shown in perspective.

78. To draw the hips *l p* and *l h*, shown in (*a*), draw from l_1 in (*c*) the lines $l_1 h_1$ and $l_1 p_1$, giving to them both a slightly altered slope toward the eaves, due to the tilting caused by the sprocket piece. The correct angle of the two slopes can be set out, as also the point where the slope changes, but in practice it is not usual to set out in detail such small features as this. In a similar manner the verges of the gable, $o_1 j_1$ and $o_1 k_1$, may be drawn. After joining $n_1 i_1$ to give the valley line of the roof, the perspective outline of the main roof will be complete. The point q_1 at the apex of the under side of the barge-board may be fixed by means of the height line H_2 and V_1. From *q* in (*b*) project a line across to cut H_2 in q_2; a vanishing line from here to V_1 will intersect a vertical representing the centre line of the barge-board at q_1. It will be noticed that q_1 is not drawn vertically under o_1, as o_1 represents the edge of the tile verge, while the face of the barge-board is back from the tile verge, and so from the point of view of the perspective q_1 will appear a little to the left of o_1, as shown. It is very necessary when drawing a perspective that thought be given to such points as this, so that the view may be a truthful representation of the object. These details are generally sketched in, as it would require too much time in practice to define accurately such details, unless the drawing is of very large dimensions. The barge-board can be completed by drawing short verticals at j_1 and k_1; the lower sides are defined by drawing vanishing lines to V_2. Finally, lines are drawn, as shown, from q_1 parallel to the lines $o_1 j_1$ and $o_1 k_1$ to meet the lower sides.

79. Bay Windows.—The corner at r_1 may be quite easily plotted from the information previously given, but slight difficulty may be encountered with the bay window. Of course it would be possible to obtain a vanishing point for all the horizontal lines in the vertical plane of $t\ u$ in (a) by drawing a line from the station point S parallel to $t\ u$ to meet the picture plane. In practice this would not be done, as the vanishing point might fall at an inconvenient distance. The simplest way to proceed is to produce $s\ r$ in (a) to meet the picture plane in H_3, and also to produce the face of the bay window $v\ u$ to meet the picture plane in H_4. In conjunction with the two height lines that are drawn at the points H_3 and H_4 and lines vanishing to V_2, it will be possible to draw all the horizontal lines on the side face of the bay window. The main vertical lines of the bay must now be drawn, and from s_2, t_2, u_2, and v_2 in (a) run down verticals to (c). From the point where H_3 cuts the ground line draw a vanishing line to V_2 cutting the vertical drawn from r_2 in r_1, thus fixing the point r_1. Produce the line to s_1 and vanish from s_1 to V_1 to cut the vertical projected from t_2 in t_1. This will give the correct line for the projection $s\ t$ in (a). The height line for horizontals on the face $u_1\ v_1$ is at H_4; therefore, from the point where H_4 cuts the ground line, draw a vanishing line to V_2 cutting the verticals projected from u_2 and v_2 in u_1 and v_1. By joining t_1 and u_1 the ground line of the bay window will be complete. In a similar way the outline of the bay at the top under the gable must be set out, as at $w_1\ x_1\ y_1$ and z_1.

80. To set out the window openings on the faces of the bay, draw lines to S from the points on plan, and project verticals down to view (c) from the points where these lines cut the picture plane in (a). The heights of the head and sill line in each case must now be obtained from the height lines H_3 and H_4. On the latter lines mark off the heights r_7, r_8, r_9, r_{10} and u_7, u_8, u_9, u_{10} by drawing lines horizontally across from the points r_3, r_4, r_5, r_6 and u_3, u_4, u_5, u_6 in view (b). Taking the window openings on the face of the bay first, from the points u_7, u_8, u_9, u_{10} draw vanishing lines to V_2 across the face $u_1\ v_1\ z_1\ y_1$ of the bay, cutting the verticals of the window openings as shown, and cutting

the vertical angle $u_1 y_1$ of the bay in the points t_3, t_4, t_5, t_6. To obtain the heights of the sills and heads on the face $t_1 u_1 y_1 x_1$ of the bay, vanish from r_7, r_8, r_9, r_{10} on H_3 to V_2 to cut the vertical corner at s_1 in four points as shown. Through these four points draw vanishing lines from V_1 to cut the vertical at t_1 in the points t_3, t_4, t_5, t_6. Lines drawn from the points t_3, t_4, t_5, t_6 on the vertical through t_1 to the similar points on the vertical through u_1 will give the correct heights and directions of the heads and sills of the windows on the side of the bay. If it is desired to add more details on the windows, these would generally be sketched in for such portions as the sill, frame, and sashes.

81. The tie beam to the gable, across the head of the bay window, can now be drawn in, and must be shown to project slightly beyond the face of the bay window. The upper side of the beam may be drawn in without constructive lines. The wooden brackets on each side of the bay must next be finished, the wall pieces to same being drawn by means of the projection r_4 in (*a*), which must be drawn vertically down to (*c*). The height of the under side of this wall piece shown at r_{15} in (*b*) is projected across to the height line H_3 in (*c*), as at r_{11}, and from this point a vanishing line is drawn to V_2 to cut the line of the wall piece in r_{12}. The extreme outer edge of the bracket is found by the projection r_{14} in (*a*), and the remainder of the bracket is drawn in by hand without further construction.

82. Chimneys.—Considering the chimney to the left, whose three visible angles are marked l_3, l_4, and l_5 in (*a*), the projection of the vertical angles is found by means of the projections l_6, l_7, and l_8 on the picture plane. The heights are obtained by producing the side $l_4 l_5$ in (*a*) to meet the picture plane in point H_5 and projecting downwards to give the height line H_5 in (*c*). On this height line mark the height of the top of the chimney stack, as at l_{12}, by projecting across from l_4, l_5 in (*b*), a vanishing line from l_{12} to V_2 giving the edge $l_{10} l_{11}$ of the chimney, the vertical edges having been projected vertically downwards from the projections on the picture plane in view (*a*). From point l_{10} draw a vanishing line toward V_1 cutting the extreme left-hand edge of the chimney in l_9, thus completing

the top of the chimney. The points l_{15} and l_{16}, where the faces of the chimney intersect the roof, may be found by projecting the points l_{13} and l_{14}, in (*b*), over to the height line H_5, fixing the points l_{17} and l_{18}. Vanishing lines drawn from the latter points to V_2 intersect projectors from l_{19} and l_8, thus fixing the points l_{15} and l_{16}. To find the projection of the chimney at the right of the house, a similar method must be adopted, the heights being determined by using the height line H_6.

83. Dormers.—To obtain a height line upon which a number of heights on the dormer can be measured, produce the line of the ridge m_3, m_4 of the central dormer, view (*a*), to the picture plane at m_5, and project it down vertically to (*c*) as at H_7. The ridge of the dormer is found in a similar manner as was employed for the ridge l_1 m_1 of the main roof. Project the points m_3 and m_4 to the picture plane as at m_6 and m_7, and from here draw projectors downwards to (*c*). On H_7 project the height of the ridge horizontally across from point m_4 in (*b*) to m_8, and from here draw a vanishing line to V_1 cutting the projectors from (*a*) in m_9 and m_{10}. The line m_9 m_{10} is the perspective of the ridge.

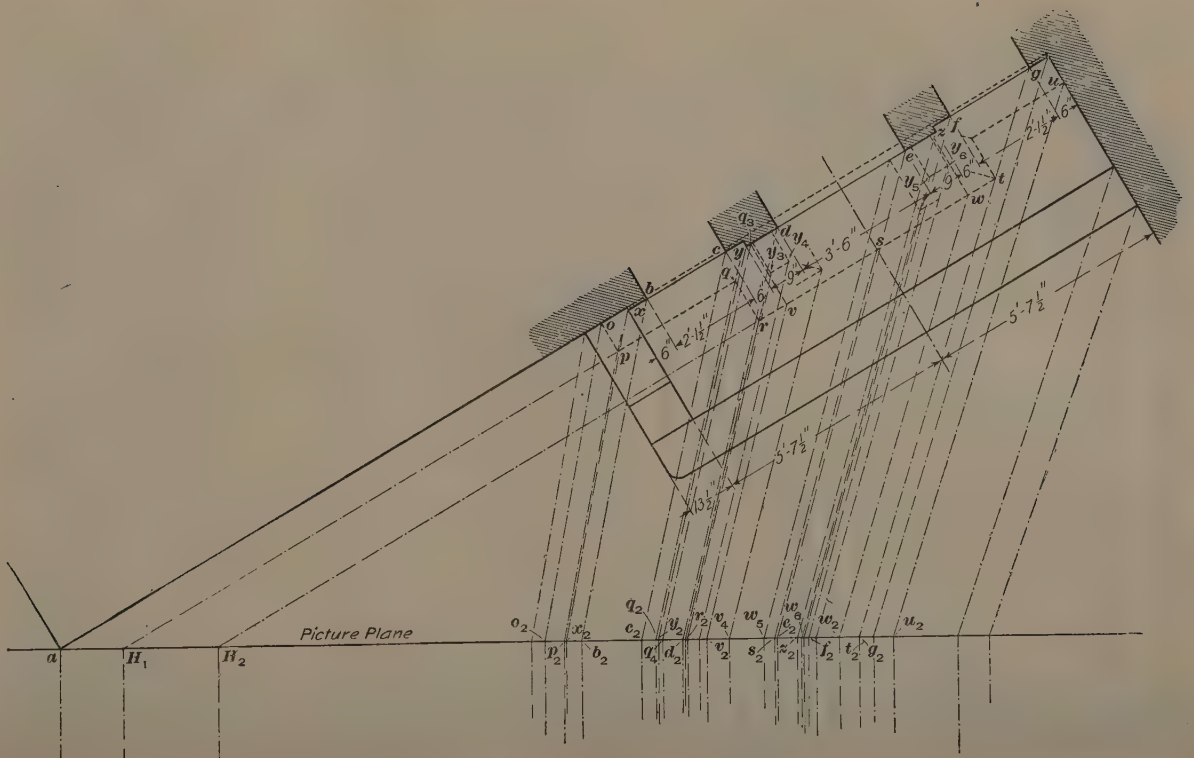
84. The point m_{13} at the centre of the face of the gutter in view (*c*) is found by first drawing a projector from m_{12} on the picture plane. A projector is then drawn from point m_{11} in view (*b*) intersecting H_7 at m_{14}, from where a vanishing line is drawn to V_1, which cuts at m_{13} the vertical from m_{12}. In a similar manner point m_{15} may be found by projecting over from m_{15} in view (*b*) to m_{16} on H_7, and from here draw a vanishing line to V_1 that will intersect a projector from m_{17} at m_{15}. By drawing a vanishing line to V_2 through point m_{13}, the points m_{18} and m_{19} at the ends of the gutter may be found by projectors from points m_{20} and m_{21} in (*a*). By means of point m_{18}, points m_{22} and m_{23} may be found in a similar manner. By a vanishing line to V_1 from point m_{18}, the point corresponding to point m_{24} in the plan may be found by projectors from (*a*). The hip lines m_{10} m_{18} and m_{10} m_{19} and the valley line running through point m_9 may now be drawn in. It is yet necessary to find a point in view (*c*), corresponding to point m_{25} in view (*a*), by projectors from (*a*), and then to draw in the line corresponding to line m_{22} m_{25}, which

is the intersection of the side of the dormer with the roof. In this case point m_{25} would probably not be worked out, but would be put in by the eye on a projector from m_{25} in view (*a*).

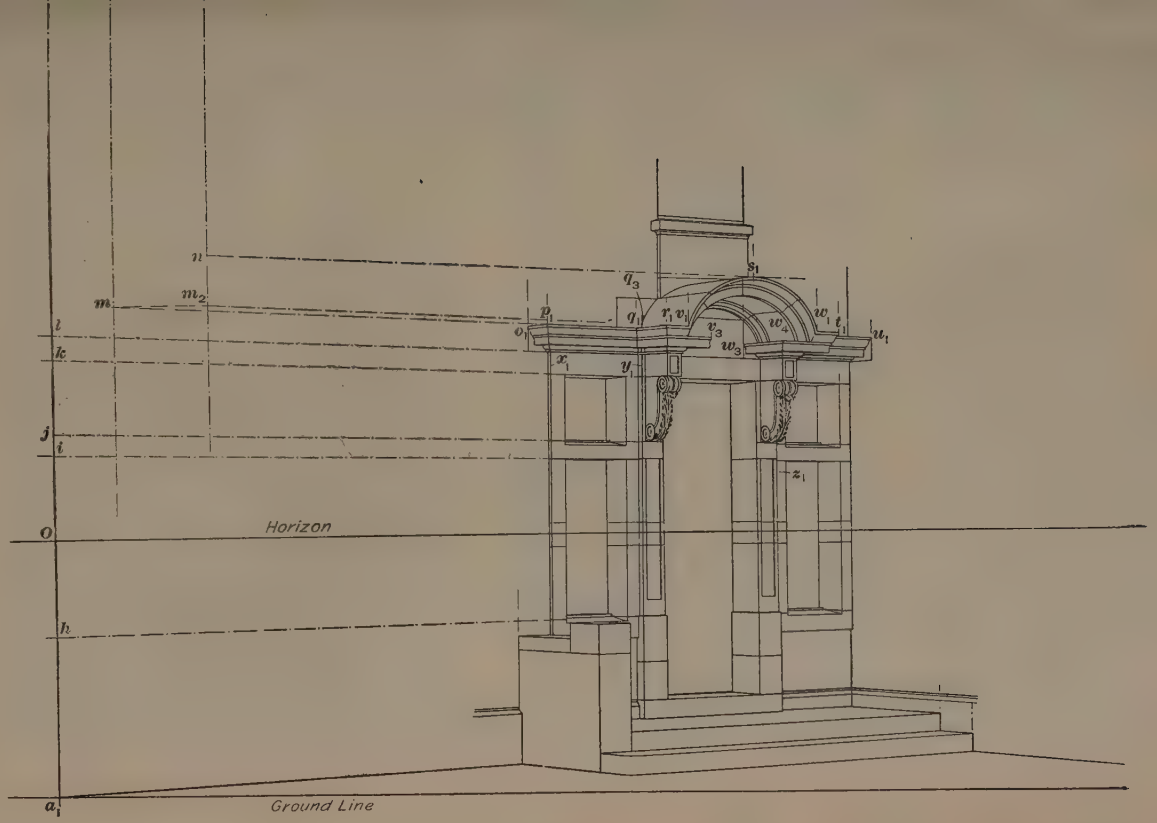
85. The dormer on the left-hand side can be drawn in a similar manner by means of the height line H_8. The windows and other details on the main front walls could be drawn by using the corner line $a_1\, b_1$ as a height line as it is in the picture plane. In conjunction with this the vertical lines are used, obtained from the projections on to the picture plane in (*a*), as before described. The insertion of the steps and the dwarf wall adjoining the entrance door needs no further explanation, as they can be drawn by applying the methods previously explained. The entrance doorway itself may present some difficulties; its working out will be treated separately in the following articles.

86. Entrance Door. — The construction work necessary to obtain the lines of the entrance door and cornice and pediment above it are omitted from Fig. 28, on account of the confusion that would result from filling in more detail. The constructive details are therefore shown separately in Fig. 29, which gives the perspective of the porch from the same point of view as in Fig. 28, but somewhat enlarged for the purpose of making it clearer. At (*a*) the plan is given and at (*c*) the perspective. The vanishing points are too far away to be shown, and the elevation is also omitted. Point *a* in (*a*) and a_1 in (*c*) represent, as before, the near corner of the building. The drawing of the dwarf wall and steps near the entrance needs no explanation, as it consists only in a simple application of the principles previously explained.

87. The vertical corners indicated on the plan at *x*, *b*, *c*, *y*, *d*, *e*, *z*, *f*, and *g* are drawn in perspective by projecting the points to the picture plane in (*a*) and drawing vertical lines through the points of projection x_2, b_2, c_2, etc. The sill, transom, and head level are obtained by marking their heights on the vertical at a_1 at the points *h*, *i*, *j*, *k*, *l* and drawing vanishing lines toward V_2, the right-hand vanishing point. It will be noticed that the slight projections in the wall line which occur at *x*, *y*,


Picture Plane
a
H_1
H_2
o_2
x_2
p_2
b_2
c_2
q_2
q_4
y_2
d_2
r_2
v_4
v_2
w_5
s_2
w_6
e_2
z_2
w_2
f_2
t_2
g_2
u_2
o
x
b
p
q
c
y
q_3
d
y_4
y_3
r
v
s
e
z
f
y_5
y_6
w
t
g
u
6"
2'-1½"
9"
3'-6"
5'-7½"
13½"

(a)


n
m
m_2
l
k
j
i
O
h
a_1
Horizon
Ground Line
q_3
s_1
p_1
q_1
r_1 v_1
v_3
w_2
w_1
t_1
u_1
o_1
w_3
x_1
y_1
z_1

(c)

FIG. 29

and z are omitted from the construction ; some slight allowance may be made for them in drawing, but they are really negligible in a drawing to so small a scale. The lowest line of the cornice has been obtained by a vanishing line toward V_2 from l, and the upper edge line must next be found. This line is given in the plan at (*a*) by the line $o\ p\ q\ r\ v\ s\ w\ t\ u$. The positions of its important points in the picture plane are o_2, p_2, q_2, etc.

88. As this outer edge line of the cornice is in front of the wall, the vertical line a_1 will not serve as a height line, but the line $u\ q\ p$ must be produced to give the height line H_1, and the line $t\ s\ r$, which is the edge of the part of the cornice that is projected still farther out on brackets, must be produced to give the height line H_2. On these height lines in (*c*) the points m and m_2, the height of the top of the horizontal part of the cornice, are marked, and on H_2 the point n is marked, giving the height of the curved pediment. Through m a line is drawn toward V_2 to intersect verticals through p_2, q_2, and u_2, fixing the points p_1, q_1, and u_1, and giving the line of the edge of the cornice over the windows beside the door. From p_1 a vanishing line drawn toward V_1 will give $p_1\ o_1$, and a vanishing line from V_1 through q_1 will give $q_1\ r_1$.

89. On the plan v and w are the end points of the curved pediment. Their projections v_1 and w_1, as well as the points r_1 and t_1, are found by a vanishing line through m_2 toward V_2 to meet verticals from r_2, v_2, w_2, and t_2. In the same way the point s_1, the highest part of the curved pediment, is fixed by a vanishing line from n toward V_2 to meet the vertical from s_2. In making a drawing to this small size it will generally be unnecessary to work out any more points for the cornice. A sufficiently correct curve can be drawn through the points v_1, s_1, w_1, and the members of the cornice can be drawn in with their lines properly vanished. The points v_3, w_3, and w_4 will be drawn vertically under v_4, w_5, w_6, as these are rather important points.

90. The brackets have now to be drawn, the outer edges of which are given in (*a*) at y_3, y_4, y_5, and y_6, and from their projections on the picture plane verticals would be drawn down

to the perspective. The bottom lines are level with the top of the transom, and with this guidance the brackets can be drawn in.

The side of the pediment which appears in the view would be drawn by the point q_3 in (*a*), where the springing line v of the curved pediment meets the wall, being projected to give q_4, whence a vertical to meet a line vanishing from m toward V_2 would give q_3. From q_3 a curve would be drawn, approximately parallel to the front edge of the pediment cornice, till it meets the vanishing line drawn from s_1 to V_1 and tangent to the curve $v_1\, s_1\, w_1$.

It should be remembered that if a detailed perspective were made to a large scale of this doorway or any other part of this house, many more lines would be necessary, but in a very small drawing it is scarcely possible to work out every detail.

FINISHING A PERSPECTIVE

91. The extent to which details may be introduced into a perspective drawing, without going through the whole process necessary to determine their exact form or position, depends on the proficiency of the draughtsman. Every part about which there is any uncertainty must be carefully worked out. After a draughtsman has gained more experience in this kind of work and is thoroughly well acquainted with the form a certain part will assume, he may dispense with a great many of the construction lines that would be absolutely necessary to a beginner. In drawing a perspective, the necessary construction lines are lightly drawn and not made longer than is necessary. When the whole drawing is complete, the construction lines are removed, if required, and the drawing finished in whatever way desired, whether in colour, pencil, black and white, or wash.

92. It is generally advisable, even with a large drawing where the vanishing points do not come on the paper, but outside, to keep the drawing fixed in its proper position in relation to the vanishing points until it is finished, because while the

drawing is progressing it may often be necessary to put in vanishing lines that have not been included in the preliminary

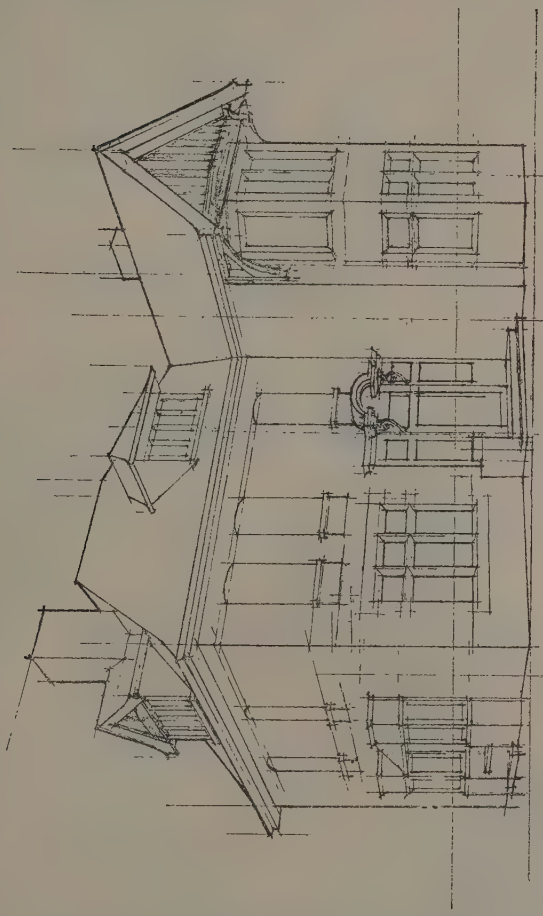


FIG. 30

work. Such lines are brick courses and similar details which would not be drawn in the actual perspective drawing, but the

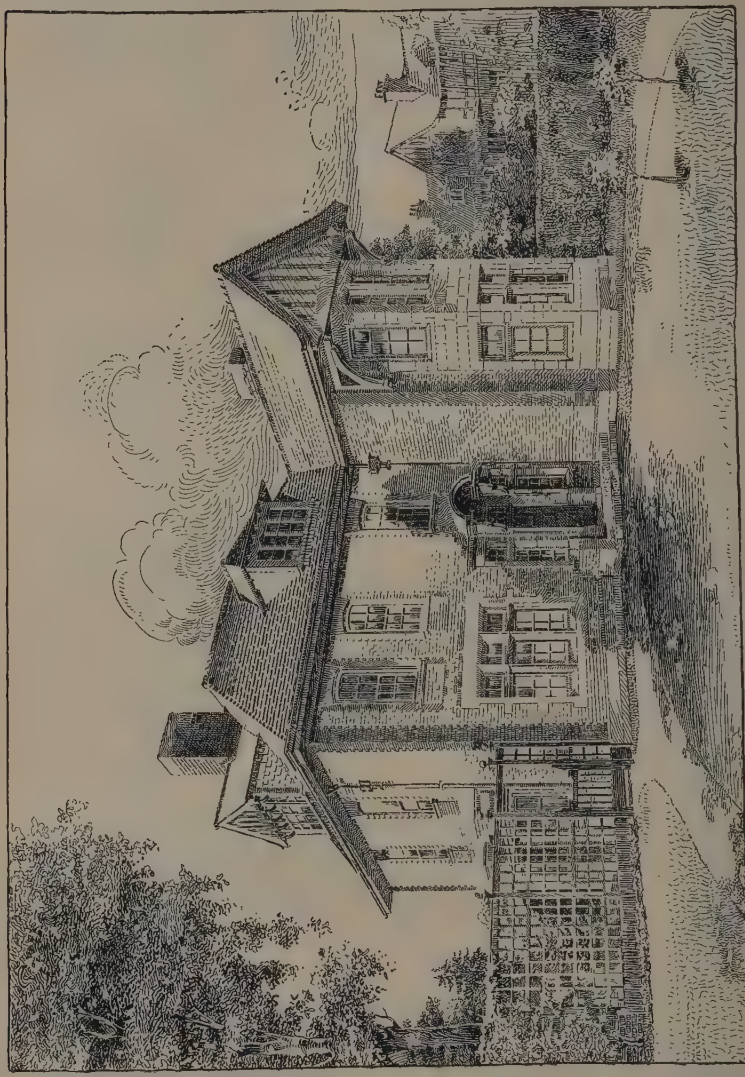


FIG. 31

accurate insertion of which would be desirable when the drawing is being finished.

93. Fig. 30 shows an enlarged view of the perspective in Fig. 28 as it would appear in pencil. Some of the construction lines have been retained, thus giving the drawing somewhat the appearance of a perspective drawing in which the construction work has been completed and the finishing is to begin. Probably the lines would be lighter than they are shown in this example, but as, in this case, the drawing is left in outline, a rather heavier line than usual has been used. In Fig. 31 is shown the perspective in its finished form after all the details have been inserted.

THE CENTROLINEAD

ADJUSTMENT AND APPLICATION

94. Description.—In small perspective drawings, and those in which the station point is at no great distance from the object, the left- and right-hand vanishing points can be easily placed on the drawing-board, and pins inserted at these points against which the straightedge may be laid while drawing all the vanishing lines.

However, occasions will arise, as in a large perspective, or where one side of the object forms a very acute angle with the picture plane, when one, or both, of the vanishing points will be situated beyond the limit of the drawing-board. The direct use of the vanishing points as foci of the vanishing lines is therefore impossible. In such cases, an instrument known as a **centrolinead** is generally used.

95. In Fig. 32 (*a*) is shown a plan view of a centrolinead. It comprises one ruling arm *a* with two adjustable arms *b* and *c*, which are connected to the arm *a* by the metal plate *d*. The slant arms *b* and *c* are fixed in any desired position by means of the thumbscrews *e*, *e*.

In conjunction with the centrolinead a couple of pins are required, of which one is shown separately in Fig. 32 (*d*). The

pin *i*, which projects below the head *g*, is pushed into the board

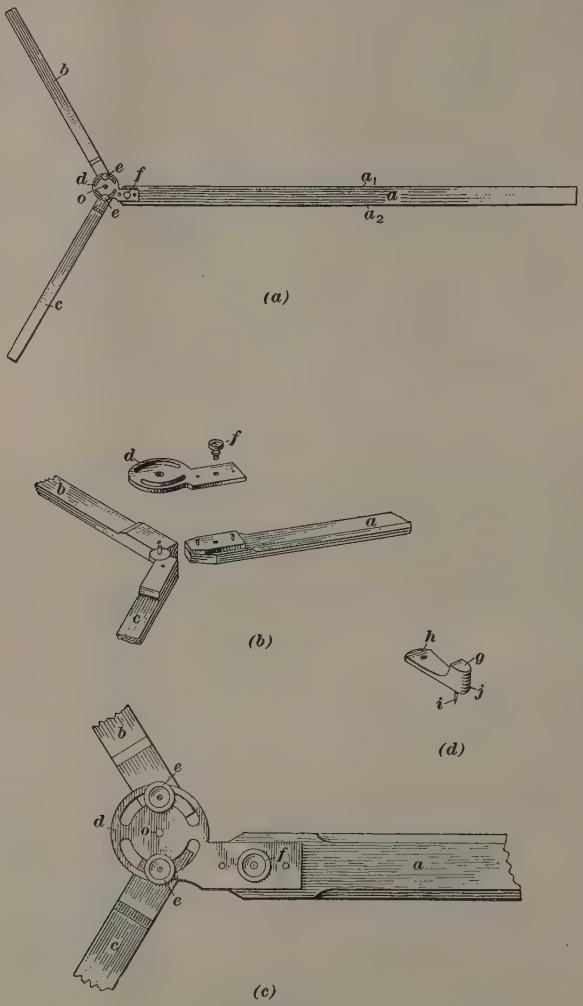


Fig. 32

and is prevented from revolving by inserting a long-pointed

drawing-pin through the hole *h*. The arms *b* and *c* of the centrolinead work against the round end *j* of the head. As shown in Fig. 32 (*a*), the centrolinead is ready for use for lines vanishing to the left ; but if it were required to use the instrument at the other side of the board for lines vanishing to the right, it would not be sufficient merely to reverse it. The three screws *e*, *e*, and *f*

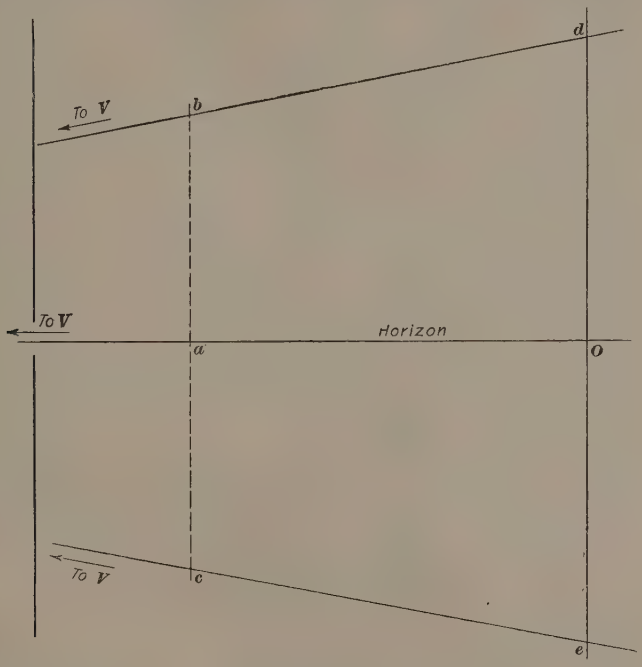


Fig. 33

must be removed and the instrument taken to pieces, as shown at (*b*) ; then the plate *d* must be turned over and the instrument screwed together again, the object of this alteration being that the ruling edge a_1 must be in line with the centre *o* of the circular part of the plate *d*. If the instrument were merely turned round, without reversing the plate *d*, the edge a_2 would become the ruling edge, and it would be found impossible to set the

instrument properly, because this edge a_2 is not in a line with the centre o.

96. Lines for Setting Centrolinead.—In order to set a centrolinead, it is necessary first of all to obtain two lines besides the horizon line which, when produced, would meet at the vanishing point toward which the lines to be drawn by the centrolinead must vanish. If possible, the drawing may be laid on the floor, the vanishing point fixed, and two vanishing lines drawn with a straightedge. The drawing may then be taken up and pinned on a board and the centrolinead adjusted.

97. If it is not possible or desirable to adopt this method, the required lines may be obtained by a problem of simple proportion. For this purpose the plan must be drawn to a small scale, the station point fixed and the vanishing point V found, and its distance from the centre of vision O on the horizon line accurately scaled. Then, on the perspective drawing, the construction shown in Fig. 33 must be made. At O is the centre of vision; from O set off $O\,a$ equal to some convenient fraction, for instance $\frac{1}{4}$, of the distance from O to V which has been found by scale from the construction just described. Through points O and a draw vertical lines and mark off $O\,d$ and $O\,e$ to some convenient length; then find the length of $a\,b$ by means of proportion in the following manner. By reason of the similarity of the two triangles $V\,O\,d$ and $V\,a\,b$, the following proportion holds true: $(V\,O - O\,a) : a\,b = V\,O : O\,d$; hence,

$$a\,b = \frac{(V\,O - O\,a)\,O\,d}{V\,O}$$

If, for instance, $V\,O = 24''$, $O\,a = 6''$, $O\,d = 8''$, then, from the above formula, $a\,b = \dfrac{18 \times 8}{24} = 6''$. The line $a\,c$ is calculated in the same manner. If the lines $d\,b$, $O\,a$, and $e\,c$ are produced, they will meet at one point, namely V.

98. Another method of finding these lines by means of a measuring point is shown in Fig. 34. After the plan has been made the measuring point of the line $a\,b$ is ascertained by marking off on the picture plane a distance $a\,h$ to the left of a equal to $a\,b$.

The points b and h are joined, and a line drawn from the station point S to the picture plane parallel to $b\,h$, thus fixing the mea-

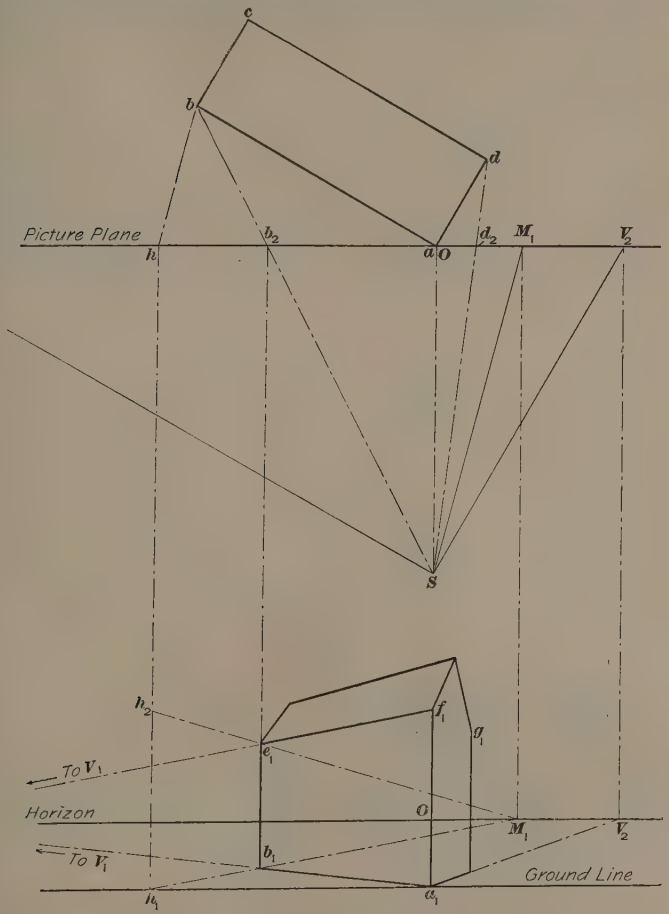


Fig. 34

suring point at M_1. The perspective drawing is now made by means of the plan, according to the principles already explained. The correct height of the corner at a is set off at $a_1 f_1$, and

points b_2 and h are projected down from the plan, and the height of $h_1\ h_2$ made equal to $a_1\ f_1$. Lines are then drawn from h_1 and h_2 to M_1, to cut the vertical from b_2 at b_1 and e_1, thus fixing these two points. Join f_1, e_1 and a_1, b_1, and these lines produced will meet at V_1 so that they may be used as guides in setting the centrolinead.

99. Adjustment.—In order to set the centrolinead according to the lines obtained by one or other of these methods, two pins d and e, of the type shown at Fig. 32 (d), are fixed in the manner shown in Fig. 32. The rounded part of these pins must be tangential to a vertical at points equidistant from the horizon.

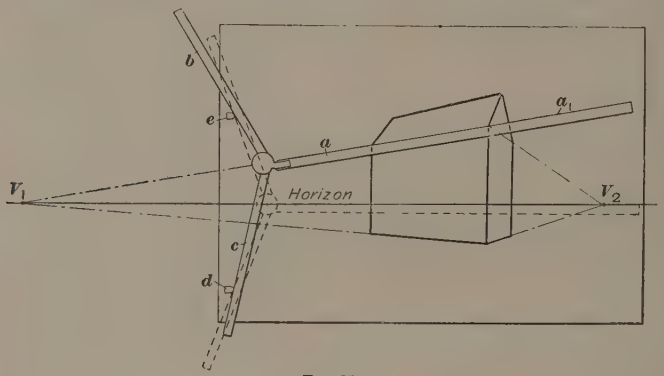


FIG. 35

The instrument may now be adjusted, generally by laying the ruling edge a_1 of the ruler a against the horizontal line, and adjusting the arms until the centrolinead may be moved so that the edge a_1 will lie accurately along each of the radiating lines, provided always that the rear edges of the arms b and c touch the pins. Fig. 35 illustrates also by dotted lines the centrolinead with its edge a_1 coinciding with the horizontal line.

100. Difficulty is sometimes experienced in correctly setting the centrolinead in the manner just described. A quicker and more accurate method is graphically set forth in Fig. 36. The convergency lines are set out as before, and the pins placed one vertically over the other at d, b as before. From point d

draw a line at right angles to the convergency line $f\,g$, intersecting the horizontal line at o. Similarly draw a line from b, which will also meet the horizontal line at o. The rule a of the centrolinead is now set to the horizontal line, care being taken that the centre of the metal plate is directly over the point o.

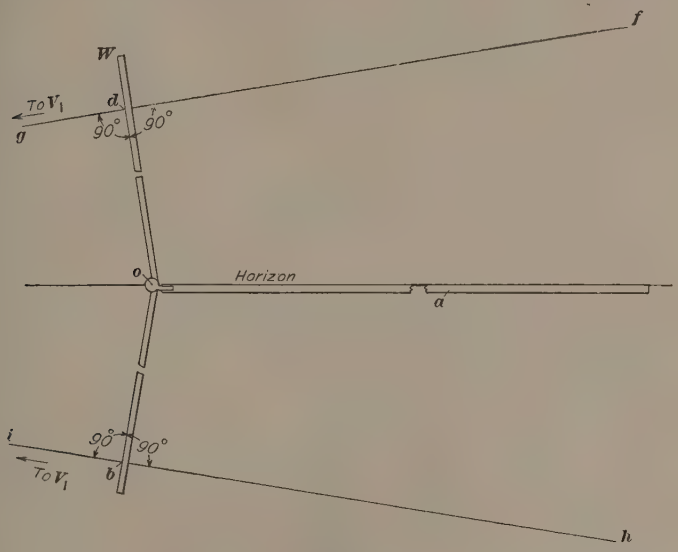


FIG. 36

It is then a simple matter to adjust the short arms until they coincide with $d\,o$ and $b\,o$, respectively. This done, the thumb-screws are tightened up, and the instrument is set ready for use. When a centrolinead is properly adjusted, any lines drawn with it, provided that the short arms are in contact with the pins, will, if produced, pass through the vanishing point.

SHADES AND SHADOWS

GENERAL PRINCIPLES

PLANES OF PROJECTION AND SOURCES OF LIGHT

PLANES OF PROJECTION

1. Introduction.—The object of inserting shadows in a geometrical drawing is to obtain a certain quality of relief, and to assist the architect, when presenting a design for a new structure, to produce an effect on the observer otherwise impossible. It is evident to anyone familiar with drawings, carefully finished with shades and shadows, that the gain from a graphic point of view is such as amply to repay the extra amount of time and labour involved in their preparation. The relief obtained by the addition of shadows is of particular advantage when the drawing is intended for a person not familiar with the principles of drawing. To such persons an ordinary projection drawing will be nearly unintelligible.

2. Care must be taken, in the matter of shading, as in other matters pertaining to the artistic side of an architect's work, that the insertion of shadows is not carried to excess, marring an otherwise carefully prepared drawing by a too elaborate treatment or too liberal use of shadow tints ; but when the object of shading a drawing is carefully kept in mind, any tendency to excessive elaboration can be avoided.

It is the purpose of this Section to give an explanation of the fundamental principles applied in the construction of shades

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and shadows ; it is not intended as an exhaustive treatment on the subject. The application of the principles involved are shown by means of various examples, and if these are thoroughly understood there should be no difficulty in constructing the shadows for any combination of parts met with in ordinary architectural drawings.

3. Horizontal and Vertical Planes.—Throughout the study of the subject of architectural shades and shadows, it will be found that when representing shadows in orthographic projection the same general rules will be observed as were described in *Geometrical Drawing* when dealing with orthographic projection. Two planes will be used, the horizontal and the vertical, and the cast shadows will be projected on either one or the other of them, or on both ; or on a body whose faces are equivalent to one or the other of them. The representation of objects will be made in a similar manner also, by means of the various kinds of lines described. The light full line will be used for drawing the outline of figures, the dotted line for concealed surfaces, and the other types of line will be used as necessary. Visible shades and shadows will be shown by covering their surfaces with section lines, and the boundaries of hidden shades and shadows will be indicated by dash-and-dot lines.

4. Formation of Shadows.—In nature three elements are required for the formation or production of a shadow ; and in the orthographic projection of shadows the three same elements must be present to obtain correct results. The first of these is a luminous point or body, giving out light in the form of rays, which on the drawing are represented by straight lines drawn at a particular angle. The second is the body casting the shadow, which must be interposed between the source of light and the surface on which the shadow is to be cast. The third is the surface receiving the shadow, represented in the drawing either by the horizontal or vertical planes or by some other object presenting similar planes to the rays. The shape of the shadow will depend entirely on the direction of the rays of light, on the shape of the object casting it, and on the shape of the surface receiving it.

SOURCES OF LIGHT

5. Natural.—When treating the subject of shades and shadows from a geometrical point of view, as is the case in dealing with architectural drawings, the first point to be decided is as regards the position of the source of light. It will be at once apparent that for all external work the only light that need be considered is that emanating from the sun. On account of its great distance from the earth its rays may be taken as virtually parallel to one another.

6. Artificial.—Different conditions exist when artificial lighting has to be taken into account, as might well be the case with elevations or perspective views of interiors. In this case the light emanates from a luminous body or a window situate at a finite distance only, and consequently the rays will be divergent, and not parallel as is the case with the sun's rays. As the working out of problems with divergent rays is not the usual practice in an architect's experience, parallel rays only will be used in this Section.

7. Angle of Light. — The usual practice when dealing with architectural shades and shadows is to assume that the rays of light emanating from the sun make an angle of 45° with the horizontal and vertical plans of projection. It will be seen that if this practice is followed the form of the shadow in a geometrical elevation, or its outline if thrown on a moulded or otherwise varied surface, is a measure of the form of the object casting the shadow, or a graphic indication of the section of the moulding or varied surface receiving it. Hence, an elevation with properly projected shadows contains in itself a general indication of surface projections and depressions, serving the purpose to a certain extent of a general perspective view.

8. Conventional Ray. — It can be proved from Fig. 1 by means of geometrical construction that if a line appears in elevation at an angle of 45° and in plan at a similar angle its actual inclination to the horizon is at an angle of 35° 16′, so that, if rays of light, which are represented by straight lines, are taken

in elevation and plan to be at an angle of 45°, the sun which projects them must be at an altitude of 35° 16′. This means

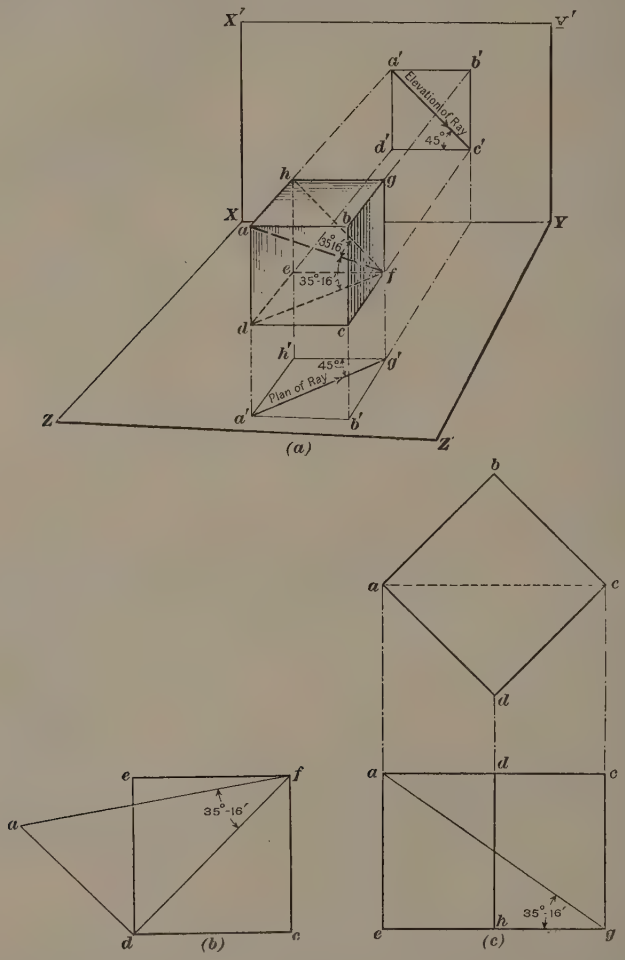


FIG. 1

that if the observer is facing the vertical plane the sun is above and behind the observer's shoulder and to his left-hand side.

It is of the utmost importance that this should be clearly understood, as it is the basis on which all problems are worked out. A line drawn at this angle is termed the *conventional ray* and indicates the conventional direction of a ray of sunlight. At $X\,Y\,Y'\,X'$ is shown the vertical plane and at $X\,Y\,Z'\,Z$ the horizontal plane. The direction of the ray is shown in elevation on the vertical plane at $a'\,c'$ making an angle of 45° with the horizontal plane. At $a'\,g'$ on the horizontal plane is shown the direction of the ray in plan making an angle of 45° with the vertical plane. Both these lines $a'\,c'$ in elevation and $a'\,g'$ in plan form diagonals of the squares $a'\,b'\,c'\,d$ and $a'\,h'\,g'\,b'$, which are the elevation and plan respectively of the cube $a\,h\,g\,b\,c\,d\,e\,f$.

9. This cube has its rear face $h\,g\,f\,e$ parallel with the vertical plane, and therefore the line $a'\,c'$ on this plane is the projection of the diagonal $h\,f$ of the face $h\,g\,f\,e$. Similarly, the bottom face of the cube $e\,f\,c\,d$ is parallel with the horizontal plane, and the line $a'\,g'$ on this plane is the projection of the diagonal $d\,f$ of the face $e\,f\,c\,d$. The only line that when projected will give a line at 45° with the horizon in plan and elevation as at $a'\,g'$ and $a'\,c'$ is the line $a\,f$ which is the body diagonal of the cube. This line will be found to incline at an angle of 35° 16′ with the planes of projection, and is the conventional ray previously mentioned.

10. That the angle at which a ray inclines to the horizontal plane is about 35° may be proved graphically in the following manner: Construct a square, as in Fig. 1 (*b*), to represent the base $c\,d\,e\,f$ of the cube shown in Fig. 1 (*a*). Draw a diagonal $d\,f$ and erect $a\,d$ perpendicular to $d\,f$ and equal in length to $d\,e$. Connect a and f by the line $a\,f$, then the angle $a\,f\,d$ will show the true inclination of a ray to the **HP**. In this view the triangle $a\,d\,f$ represents the triangle $a\,d\,f$ of view (*a*). It is assumed that this triangle is rotated about its base $d\,f$ in view (*b*) so as to lie in the **HP**. The sides $a\,d$ and $d\,f$ will then be shown with their true lengths, and the angle $a\,f\,d$ will give the correct angle of inclination of the line $a\,f$, which represents the direction of a ray. On measuring this angle with a protractor, it will be found a little larger than 35°. It should be exactly 35° 16′.

Another and simpler method for finding the inclination of the ray is shown in Fig. 1 (*c*), which represents the same cube in plan and elevation. By drawing the diagonal *a g* the angle *a g e* will be the true angle of inclination of a conventional ray.

DEFINITIONS

11. Shade Lines and Shadows.—When the light from a luminous body falls on an opaque body, that surface or part of the opaque body which intercepts the rays of light is the illuminated part of the body and is said to be *in light*. The surfaces beyond the influence of the rays of light and on which the light does not fall directly are said to be *in shade*. The line of separation between the illuminated part of the body and the part in shade is termed the *shade line*, or the *line of shade*. If a number of the rays of light emanating from a luminous body are intercepted by an opaque body, there will exist a space beyond the opaque body from which the rays are excluded. This dark space is called the *shadow in space* of the opaque body. When an opaque surface extends into this dark space, a dark patch will appear on it which will be the *superficial shadow* or simply the *shadow* of the body producing the shadow in space.

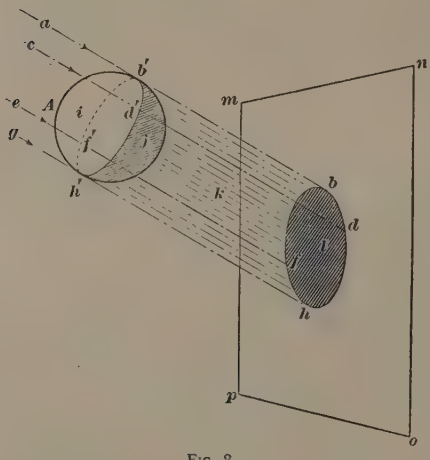


FIG. 2

12. In Fig. 2 at *A* is shown a sphere in space. The direction of the rays of light are shown by the lines *a b*, *c d*, *e f*, *g h*. The portion *i* of the sphere is in light, while the portion *j* is in shade. The line of shade is shown at *b' d' h' f'*, and is seen to be on the line

of contact of the rays with the body. At *k* is shown the shadow in space, while at *l* is shown the shadow *b d h f* of the sphere *A* cast on the opaque plane *m n o p*. As the boundary line of a shadow is determined both by the nature of the surface receiving it as well as by the contour of the body causing it, the solution of most of the problems in shades and shadows depends to a large extent on finding the shade line.

13. Difference Between Shades and Shadows.—In Fig. 3 is shown at *a* a square slab resting on a prism *b*, by means of which the difference between a shade and a shadow may be clearly indicated. That part *c* of the prism *b* which by the intervention of the slab *a* is deprived of the immediate action of the light is said to be in shadow, and *c* itself is a shadow cast by the corner of the slab. The sides *d* of the prism itself and *f* of the slab are in shade, and *e* is the shadow cast by the prism *b* and slab *a* on the ground.

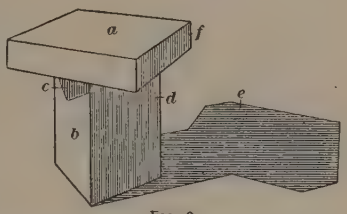


FIG. 3

14. Gradation of Shadows.—The lightest planes will be those that are at right angles to the direction of the light rays, and for the same reason the shadows on these planes will be the darkest. The darkest shadows are thus usually in close proximity to the highest lights. In general, the shades will be lighter than the cast shadows, light being reflected back into these shade surfaces from the illuminated parts that surround them. Of course, in a finished drawing, many minor tones and the presence of reflected lights will greatly help its appearance; but these matters are somewhat beyond the scope of the subject dealt with in this Section.

15. Geometrical Terms.—To distinguish between the horizontal and vertical projections of a figure, or, in other words, to distinguish between the plan and elevation, accents will be added to the *italic* letters denoting points on a figure in plan to represent the same points in elevation. Thus, in referring to

a line $A\,B$, it will be denoted in the plan by $a\,b$ and in elevation by $a'\,b'$. In dealing with the shadows of objects, capital letters will be used to distinguish the outline of shadows on the planes.

16. The line $X\,Y$, sometimes called the ground line, is really the line of intersection of the horizontal and vertical planes of projection, and when dealing with a plan it represents a plan view of the vertical plane, but when shown in an elevation it corresponds to an elevation of the horizontal plane. In the exercises worked out in this Section it will be called the $X\,Y$.

17. The horizontal plane will in all cases be designated by the letters **HP** and the vertical plane by the letters **VP**. When working out problems of shades and shadows in orthographic projection, similar planes of projection are constantly used, although they may not be specifically designated as **HP** and **VP**. It will at once be realized that flat roofs, pavements, tops of cornices, window sills, and parapets, treads of stairs, floor surfaces in interiors, and other such horizontal planes correspond to the **HP**, while general wall surfaces, risers of stairs, vertical faces of mouldings, string-courses, etc., correspond to the **VP**.

APPLICATION OF PRINCIPLES

PROJECTION WITH PARALLEL RAYS

SHADOWS OF POINTS AND LINES

18. It is of course understood that a line has no thickness, so that it cannot cast a shadow; but for the purpose of the problems of this Section, the existence of an opaque line is assumed. A line is simply made up of a number of points, so that if a right line is being considered it will be sufficient to determine the projections of the shadows of the points at its two ends and join these on whichever plane they occur. In the following six exercises the projections of a line $A\,B$ are given, and it is desired to determine its shadow in each case on the planes of projection.

19. Line at Right Angles to HP.—In Fig. 4 is shown the elevation $a'\,b'$ of a line standing vertically on the **HP**, and at b is shown its plan. It is required to find the correct shadow that this line will cast, supposing it to be opaque. From b' draw a line $b'\,c$ representing a ray of light at an angle of 45° with $X\,Y$ until it cuts this line at the point c. The line is drawn at an angle of 45° because the rays of light are supposed to fall at 45° in elevation, and consequently the shadow of the point b' will be simply at the point c on the **HP** where a ray of light passing through the point b' would cut the plane. From the point c drop a line $c\,d$ indefinitely and at right angles to $X\,Y$. Now draw a line representing a ray at an angle of 45° with $X\,Y$ from the point b until it cuts the line $c\,d$ at the point B. Join $b\,B$, when $A\,B$ will be the shadow of the line $a'\,b'$ on the **HP**.

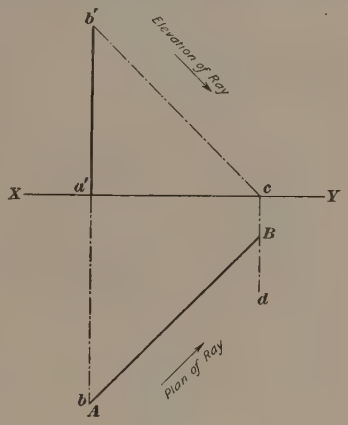


Fig. 4

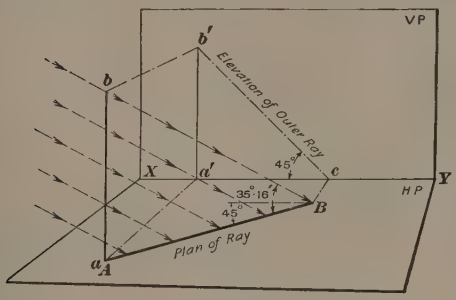


Fig. 5

20. The relations between the rays of light, the line, and its shadow may be more clearly seen from Fig. 5, which shows the **HP** and **VP** of Fig. 4 in perspective. In this view, $a\,b$ represents the line with its vertical projection $a'\,b'$ and the shadow $A\,B$. A series of light rays are indicated by arrows making an angle of 35° 16′ with **HP**. Only such rays are shown

that, passing through the line, determine the position and length of the shadow.

21. In Fig. 6 is shown a similar problem to that given in Fig. 5, but the line is longer, and consequently part of its shadow falls on the **HP** and part on the **VP**. Let $a'\,b'$, Fig. 6, be the elevation of the line and the point b its plan. From b', as before, draw a line of indefinite length representing the elevation of a ray at an angle of 45° with $X\,Y$, and from the point b draw a similar line until it cuts $X\,Y$ at the point B. From B draw a line at right angles to $X\,Y$ until it cuts the ray drawn from b' at the point C. The shadow of the line $a'\,b'$ will be $A\,B\,C$, the portion $A\,B$ resting on the **HP** and the portion $B\,C$ upon the **VP**. Of course, if the **VP** were removed, the shadow of the line $a'\,b'$ on the **HP** would be determined by the intersection at C' of $b'\,C'$ and $A\,C'$.

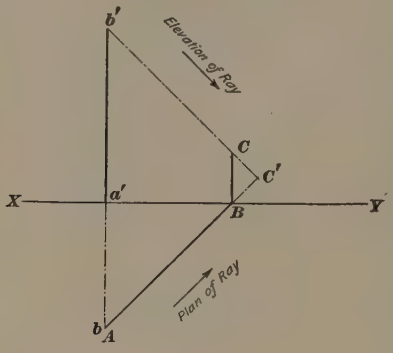


Fig. 6

22. Fig. 6 is shown in perspective in Fig. 7. It is seen from this view that the ray which passes through the point b of the line $a\,b$ would throw a shadow at C' if the **VP** were removed, thus allowing the whole length of the shadow $A\,B\,C'$ to be cast on the **HP**. By interposing a **VP**, the ray through the point b will be intercepted

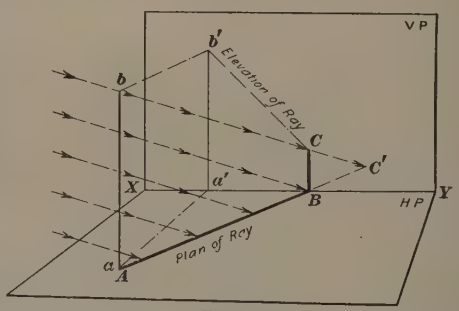


Fig. 7

at C, and the part BC' of the shadow on the **HP** is replaced by the part BC. The other parts of this view correspond with those of Fig. 5.

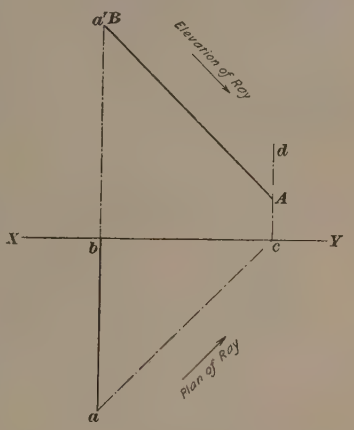


Fig. 8

23. Line at Right Angles to the VP.—In Fig. 8, at a', is shown the elevation of a line standing at right angles to the **VP**, and at $a\,b$ is shown its plan. From a draw a line $a\,c$ at an angle of 45° with $X\,Y$, intersecting it at point c; at the latter point erect a line $c\,d$ at right angles to $X\,Y$ and of indefinite length. Then, from a', draw the line $a'\,A$ at an angle of 45° with $X\,Y$ intersecting the line $c\,d$ at the point A. Then, $B\,A$ is the shadow on the **VP** of the line $a\,b$.

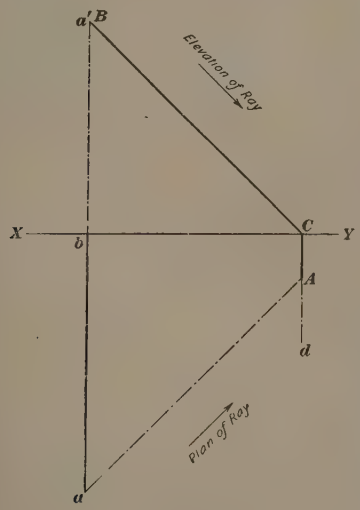


Fig. 9

24. In Fig. 9 is shown a similar example to that given in Fig. 8, but the line is longer, and part of its shadow falls on the **VP** and part on the **HP**. At a' is shown the elevation of the line, and at $a\,b$ its plan. From a' draw the line $a'\,C$ at an angle of 45° with $X\,Y$ and cutting it at the point C; from C drop a line $C\,d$ at right angles to $X\,Y$ and of indefinite length. Then, from a, draw a line at an angle of 45° with $X\,Y$ cutting the line $C\,d$ at the

point A. Then, $B\,C\,A$ is the shadow of the line $a\,b$, and the portion $B\,C$ falls on the **VP**, while the portion $C\,A$ falls on the **HP**.

25. Figs. 10 and 11 show perspective views of the lines and shadows indicated in Figs. 8 and 9. As the same letters are

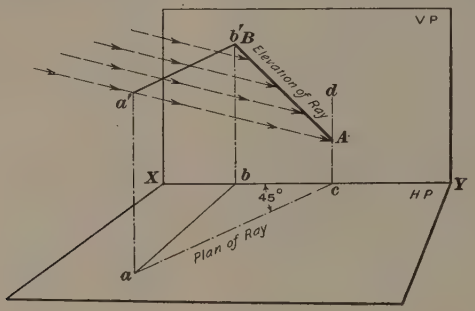


Fig. 10

used in all the figures, no additional explanation is required. The rays of light indicated by the arrows show how the shadows of the lines are produced. In these and the other illustrations

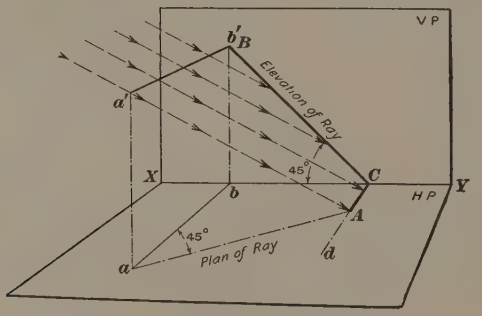


Fig. 11

where rays are shown in perspective only a few rays are indicated, and these are represented as if penetrating the lines of which the shadows are to be found.

26. Line Horizontal and Inclined at 45° to VP.—In Fig. 12 is shown at $a'\ b'$ the elevation of a line which is parallel to **HP** and inclined at an angle of 45° to the **VP**, as shown at $a\ b$. To find the shadow of this line, produce the line $a\ b$ until it cuts $X\ Y$ at the point c, and from c erect a line $c\ d$ at right angles to $X\ Y$ and of indefinite length. From a' and b' draw lines at an angle of 45° with $X\ Y$ until they cut the line $c\ d$ at the points A and B, then $A\ B$ is the shadow of the line $a\ b$ on the **VP**.

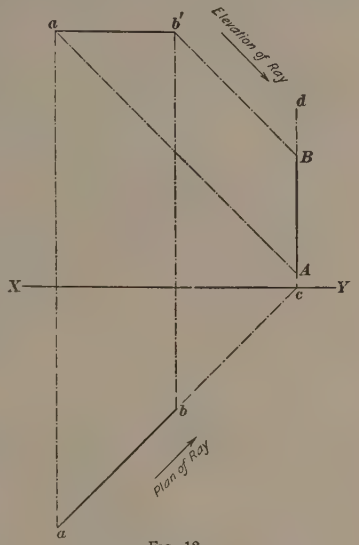


Fig. 12

27. Fig. 13 gives a perspective view of the construction shown in Fig. 12. The same reference letters are used in both, with the exception of those on the line itself, which in Fig. 13 is indicated

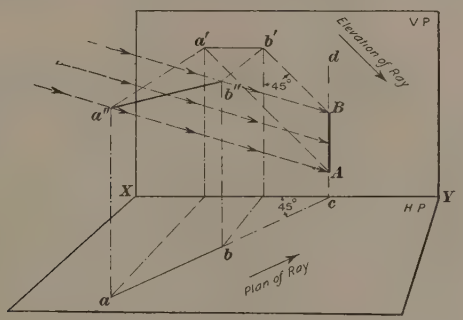


Fig. 13

by the letters a'' and b'' so as to distinguish between the line

and its projections. It is evident from Fig. 13 that the line $a'' b''$, its plan $a\,b$, its shadow $A\,B$, and the rays all lie in one plane which is vertical to the **HP** and inclined at an angle of 45° to the **VP**.

28. Line Inclined to Both Planes of Projection.—In Fig. 14 is shown at $a'\ b'$ the elevation and at $a\ b$ the plan of a right line inclined at an angle to both the horizontal and vertical planes. The problem of finding its shadow is more difficult than those previously worked out, where the line was parallel to one of the planes. First find the shadow of the portion cast on the **HP**, and from b draw a line $b\,f$ of indefinite length at an angle of 45° with $X\,Y$, and from b' draw a similar line cutting $X\,Y$ at the point c. From c drop a line at right angles to $X\,Y$ cutting the line $b\,f$ at the point B. It will be seen, from previous examples, that B is the shadow of the point b' on the **HP**. To find the direction of the shadow cast by the line $a\,b$ on the **HP**, the shadow of the point a' on the **HP** must be found. To do this the **HP** must be extended; that is, in finding the shadow of the point a', the plane above $X\,Y$, which is usually taken to be the **VP**, may be supposed to have been removed for the purpose of finding the shadow of a' on the **HP**. From a' draw a line at an angle of 45° with $X\,Y$, cutting it at d, at which point erect a line $d\,g$ of indefinite length, which will be intersected at A' by a line drawn from a at an angle of 45° with $X\,Y$. Then,

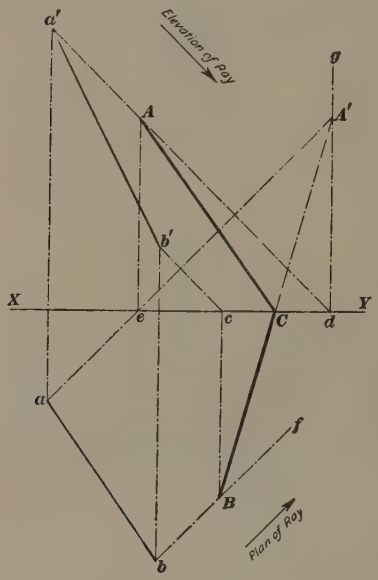


FIG. 14

A' is the shadow of the point a on the **HP**. The line connecting A' and B will be the shadow of the line $a\,b$ on the **HP**. As this shadow will cut $X\,Y$ at the point C, it will be seen that the portion $A'\,C$ would really fall on the **VP**, while the portion $C\,B$ is on the **HP**, as shown.

29. The direction of the portion of the shadow on the **VP** has next to be found, and the shadow of the point a on the **VP** must first be determined. From e, the point where the line $a\,e\,A'$ cuts $X\,Y$, erect the perpendicular $e\,A$, intersecting the line $a'\,d$ at A. Then, A is the shadow of the point a on the **VP**. As the line $a'\,b'$ is a right line, the shadow it casts must

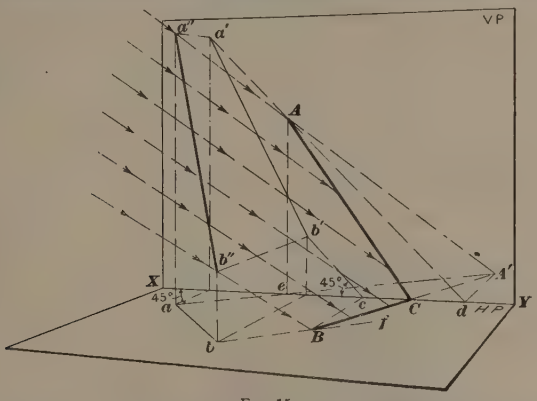


FIG. 15

be a right line ; but as it is inclined at a different angle to the **HP** and **VP**, its shadow in projection on the two planes will be broken at the point C, where its shadow on the **HP** cuts the **VP**. Two points A and C in the shadow of the line $a\,b$ on the **VP** have been found, and if they are joined $A\,C$ will be the part of the shadow cast on the **VP**. Then, $A\,C\,B$ is the shadow of the line $a'\,b'$, inclined at an angle to both planes of projection.

30. A clearer understanding of the principles involved in this problem may be obtained by a careful study of Fig. 15, which is a perspective view of the construction given in Fig. 14.

The line itself is indicated by the letters $a''\ b''$. If the **VP** is removed, then the shadow of the line will be $B\,C\,A'$, the point A' being the point of intersection between the ray through point a'' and its plan $a\ e\ A'$, drawn at an angle of 45° to $X\,Y$. With the **VP** in place, the ray through a'' is intercepted by the **VP** at point A, which point is determined by projecting point e on line $a'A$, drawn at 45° to $X\,Y$. The remaining part of the illustration is easily understood by reference to Arts. **28** and **29** and Fig. 14.

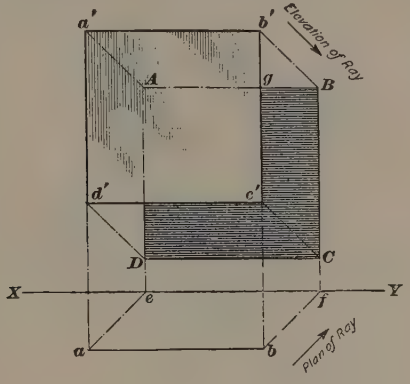
SHADOWS OF PLANE FIGURES

31. A Square Parallel to the VP.—In Fig. 16 (*a*), at $a'\ b'\ c'\ d'$, is shown a square, whose plan is represented by the line $a\,b$. It will be seen that the edges of the square are horizontal and vertical, and its face parallel with the **VP**. To determine the shadow cast by this square, proceed as before described when finding the shadows of right lines. From a draw a line at an angle of 45° with $X\,Y$ cutting it at the point e, and at e erect a perpendicular of indefinite length. From a' draw a ray at an angle of 45° with $X\,Y$ cutting the perpendicular erected from the point e at A. In a similar manner, from b draw the ray $b\ f$, and from b' draw $b'B$, cutting the perpendicular erected from the point f at B. $A\,B$ will then be the shadow of the line $a'\,b'$ on the **VP**. From d' and c' draw rays at an angle of 45° with $X\,Y$ cutting the perpendiculars erected from e and f at the points D and C. The line connecting points C and D will be the shadow of line $c'\,d'$. Join $A\,D$ and $B\,C$, then $A\,B\,C\,D$ will be the boundary lines of the shadow of the square $a'\,b'\,c'\,d'$ upon the **VP**. The square with its shadow is shown in perspective in Fig. 16 (*b*), the same letters of reference being used in both views, except that the elevation of the square is indicated by $a''\,b''\,c''\,d''$.

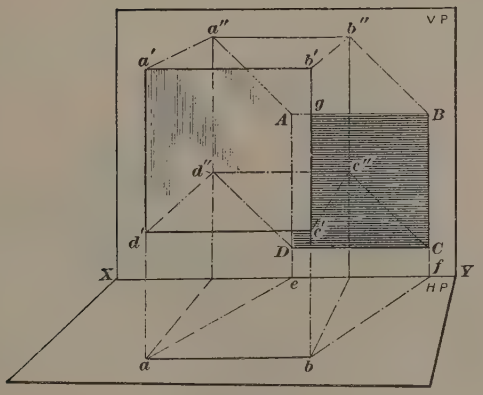
From this exercise the following rule may be stated:

Rule.—*When a plane figure is parallel to the plane receiving its shadow, the rays being inclined at an angle of 45° in plan and elevation, then the shadow is similar to the figure projecting it, its displacement, measured parallel to and perpendicular with the $X\,Y$, being equal to its distance in front of the given plane.*

32. Circular Disc Parallel to the VP.—In Fig. 17 (*a*) is shown the plan *a b* of a circle whose elevation is shown as a circle with the centre *c'*. As the circle is parallel to **VP**, it follows from



(*a*)



(*b*)

FIG. 16

the rule in Art. **31** that the shadow of that portion of the circle thrown on the **VP** will be part of a circle, and that both circles will have equal diameters. It is necessary to find the centre on the **VP** for that portion of the shadow thrown on it. From

the point c, the position of the centre of the circle in **HP**, draw a line at an angle of 45° with $X\,Y$, meeting it at the point d, and from d erect a perpendicular of indefinite length. From the point c', the centre of the circle in **VP**, draw a ray $c'\,C$ at

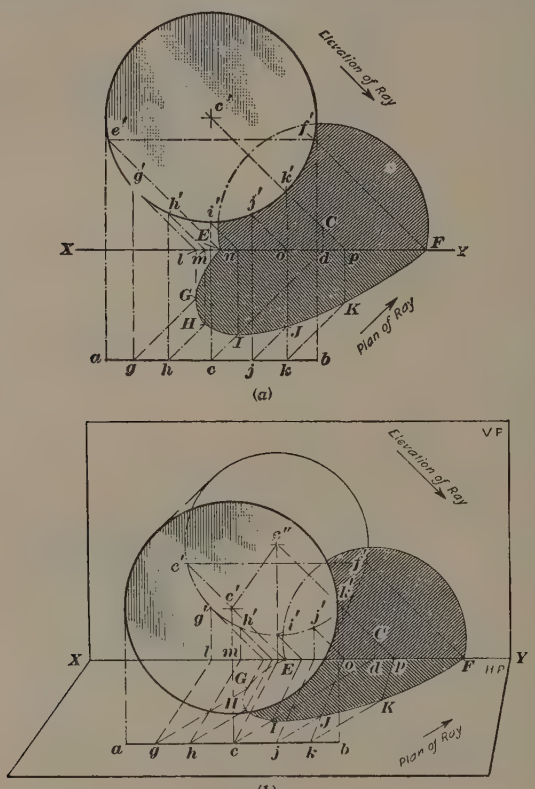


FIG. 17

an angle of 45° with $X\,Y$ cutting the perpendicular erected from d at the point C. From C, with a radius equal to the radius of the original circle casting the shadow, draw in the part of the circle forming the shadow of the circle on the **VP** and intersecting the line $X\,Y$ at the points E and F.

33. To find the shadow situated in **HP**, draw rays from the points E and F cutting the circumference of the elevation of the circle at the points e' and f'. Join e' and f'; then the portion of the circle above the line $e'f'$ will be the portion casting the shadow on the **VP**, while that portion of the circle below the line $e'f'$ will be the portion casting the shadow on the **HP**. To find the outline of the shadow on the **HP**, divide that portion of the circumference of the circle below the line $e'f'$ into any number of parts, as $e'g'$, $g'h'$, etc., and drop vertical projectors down from these points to denote similar points on the plan, as at g, h, c, j, k. From the points g', h', i', j', k' in the elevation draw rays until they cut line XY in the points l, m, n, o, p, from each of which points drop lines of indefinite length at right angles with XY. Now, from the points g, h, c, j, k, draw rays until they cut the perpendiculars dropped from the points l, m, n, o, p in the points G, H, I, J, K. A curved line through the points E, G, H, I, J, K, F will be the boundary line of the shadow of the circle on the **HP**. Of course, any number of points can be taken on that portion of the circumference of the circle below the line $e'f'$, and the greater the number taken the more accurate will be the outline of the shadow; but for all practical purposes the number taken in Fig. 17 (*a*) is quite sufficient. Fig. 17 (*b*) is a perspective view of the construction shown in Fig. 17 (*a*).

34. Shadow on Two Vertical Planes and on the HP of a Rectangular Plane Parallel to the VP.—In Fig. 18 is shown the plan and elevation of two vertical planes $a\,b$, $b\,c$ meeting at a right angle at b, the intersection being represented in the elevation by line $b'\,b''$. As these planes are supposed to be extended indefinitely, their outlines are not indicated in the elevation. The vertical plane has here been omitted, as both stand at right angles to the **HP**. In front of these two planes is plane $d\,e$, which, as shown in the elevation at $d'\,e'\,f'\,g'$, has its lower side parallel to **HP**. It is required to find the outline of the shadow cast by this plane on the two vertical planes meeting at an angle and on the **HP**. As before, proceed to find the shadows of the boundary lines of the plane figure $d'\,e'\,f'\,g'$ by first finding

the shadow of the point e' on the **VP** $b\,c$. From e in **HP** draw a ray intersecting the plane $b\,c$ in h, and from h draw a vertical projector to intersect at E a ray drawn from e'. Then, E is the shadow of e' on the plane $b\,c$. In a similar way draw a ray from f' to cut the projector from h in F. The line $E\,F$ is the shadow of $e'\,f'$ on the **VP** $b\,c$.

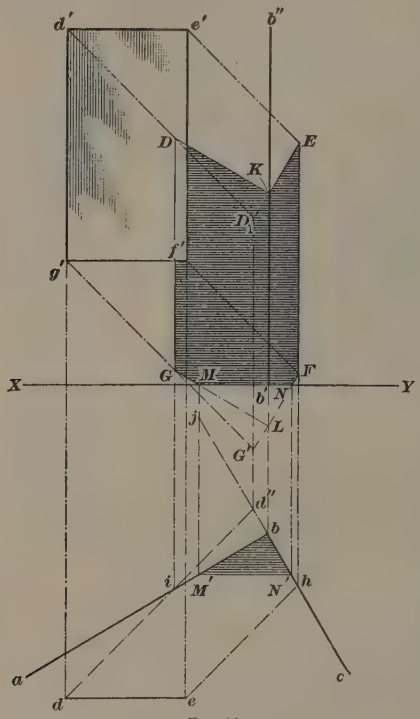


Fig. 18

35. To find the shadow of the line $d'\,g'$ on the plane $a\,b$, draw a ray through d in **HP**, as this is the plan of the points d' and g', until it cuts the plane $a\,b$ in i. Through i draw a vertical projector, which will be intersected by rays from d' and g' in the points D and G. Join $D\,G$; then this will be the shadow of $d'\,g'$ on the plane $a\,b$. It will now be seen that although $d'\,e'$ and $g'\,f'$ are straight lines, their shadows will not be straight lines, as the two points $D\,E$ and $G\,F$ are in different planes that are not parallel to $d'\,e'$ or $g'\,f'$, so that straight lines connecting D, E and G, F would not give the correct shadow of $d'\,e'$ and $g'\,f'$ on the elevation of the two planes $a\,b$ and $b\,c$.

36. It is first necessary to find the direction of the entire shadow of the line $d'\,e'$ on the plane $b\,c$, assuming that the plane $b\,c$ is extended as shown by the dotted line $b\,j$ in the **HP**.

Through d in the latter plane draw a ray to cut the plane $b\,c$ extended in d'', and through d'' draw a projector vertically intersecting at D_1 the ray drawn from d'. The line $D_1\,E$ will be the complete shadow of $d'\,e'$ on the plane $b\,c$ extended. Now, $b'\,b''$ is the elevation of the point b or the intersection of the two planes $a\,b$, $b\,c$, so that the point K, where the shadow $D_1\,E$, cuts the line $b'\,b''$, indicates the extent of the actual shadow of $d'\,e'$ on the plane $b\,c$. Therefore, the only portion of the shadow of the line $d'\,e'$ on the plane $b\,c$ is the portion $E\,K$, which also represents its direction. The shadow of the point d' at the other end of the line $d'\,e'$ on the plane $a\,b$ has been found at D. The line $D\,K$ will represent the shadow of the remaining portion of the line $d'\,e'$ on the plane $a\,b$ both in magnitude and direction. Then, $D\,K\,E$ is the correct shadow of the line $d'\,e'$, the top boundary of the plane figure $d'\,e'\,f'\,g'$, on the two planes $a\,b$, $b\,c$.

37. The lower edge $g'\,f'$ must be dealt with in a similar way. First find the shadow of g' on the plane $b\,c$ extended. As d in **HP** is the plan of g', the same ray and projector will serve for both points. All that is necessary is to draw a ray from g' cutting $d''\,D_1$ in G'. Then, G' is the shadow of g' on the plane $b\,c$ extended. The shadow of f' at the other end of the line $g'\,f'$ is the point of intersection F between a ray from f' and the vertical projector $h\,F$. The line $G'\,F$ will be the shadow of $g'\,f'$ on the plane $b\,c$. This shadow cuts the line $b'\,b''$, or the intersection of the two planes, at L. By joining $G\,L$, the direction will be found of the portion of the shadow of the line $g'\,f'$ cast on the plane $a\,b$. Both these shadows $G\,L$ and $F\,L$ are cut by the $X\,Y$, or ground line, at M and N, so it is evident that the shadow of the line $g'\,f'$, besides being partly on the planes $a\,b$ and $b\,c$, is also partly on the **HP**.

38. To find the portion of the shadow of $g'\,f'$ on the **HP**, draw vertical projectors from the points M and N to cut the two planes $a\,b$, $b\,c$ in the points M' and N'. The line $M'\,N'$ will limit the portion of the shadow of the line $g'\,f'$ that falls on the **HP**. To prove this, it will be seen that M is the point where the portion of the shadow of $g'\,f'$ on the plane $a\,b$ cuts

the line $X\,Y$, and M' is the same point in plan. In a similar way, N is the point where the portion of the shadow of $g'\,f'$ on the plane $b\,c$ cuts the line $X\,Y$, and N' is the same point in plan. As $g'\,f'$ is parallel to the **HP**, the portion of the shadow cast by it on to the **HP** must be a straight line, and as two points M' and N' in that straight line have been found, a line connecting these points will represent the portion of the shadow cast by $g'\,f'$ on the **HP**.

39. The boundary lines of the whole of the shadow of the plane figure $d'\,e'\,f'\,g'$ on the two planes $a\,b$, $b\,c$ and on the **HP** have now all been found, but to make the working out of this

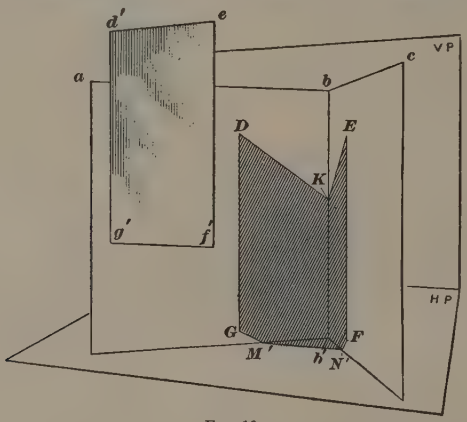


Fig. 19

exercise more clear, a perspective view is given in Fig. 19 of the three planes, with the rectangular plane and its shadow. Similar letters refer to the same parts in both figures. In order that the illustration may be made clearer, the extents of the planes $a\,b$ and $b\,c$ have been limited, as shown. The **VP** is indicated in Fig. 19.

SHADOWS OF REGULAR SOLIDS

40. In projecting the shadow of a solid figure, the *shade line*, or line of separation between surfaces in light and shade, must be obtained. In a solid bounded by planes, this shade line will

be composed of edges or arrises, and these may usually be determined by inspection. When, however, any uncertainty exists, the shadows of the several edges may be separately obtained, and as these form the boundary lines of the shadow surface, they will determine the outline of the shadow. The shadow of a solid is virtually the shadow of its shade line.

41. A Cube Resting on the HP With Its Rear Vertical Face Inclined 30° to the VP.—In Fig. 20 at *a b c d* is shown the plan of a cube with its side *c b* inclined at an angle of 30° to the **VP**. At *h′d′b′f′* is shown the elevation of this cube standing on the **HP**. It is seen by observation that the faces *a′ b′ f′ e′* and *b′ c′ g′ f′* of the cube are in shade; the shade line therefore comprises the vertical edges *c′ g′* and *a′ e′* together with the edges *c′ b′*, *b′ a′* of the top face. The shadows of the lines *g′ c′*, *c′ b′*, *b′ a′*, and *a′ e′* will therefore determine the outline of the shadow of the solid.

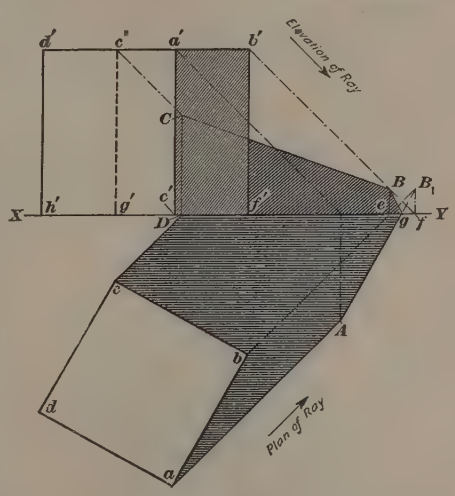


FIG. 20

42. The simplest way of obtaining the shadow cast by the cube is to obtain separately the shadow of each of the lines *g′ c′*, *c′ b′*, *b′ a′*, and *a′ e′*. The shadow of *g′ c′* is found as explained in Art. **20**, for it is a line standing vertically on the **HP**, with its elevation at *g′ c′* and its plan at *c*. Its shadow is indicated by the line *c D C*. The shadow of the line *a′ e′* is found in a similar manner, and is shown at *a A*. To find the shadow of the point *b′* on the **VP**, draw a ray from *b′* of indefinite length, and

from b draw another ray cutting $X\,Y$ at e. Draw a line from e perpendicular to $X\,Y$ cutting the ray, drawn from b', at B. Then, B is the shadow of the point b' on the **VP**. Join $C\,B$, which is the shadow of the line $c'\,b'$ on the **VP**.

43. The shadow of the line $a'\,b'$ is not a straight line joining A and B, as part of its shadow rests on the **HP** and part on the **VP**. The simplest way of determining its shadow is first to find its shadow on the **HP**, and then, from the point where this shadow cuts $X\,Y$, to draw a line to B. To find the shadow of $a'\,b'$ on the **HP**, draw a ray from b' cutting it at the point f, at which point erect a perpendicular of indefinite length. Produce the ray drawn from b to e until it cuts this perpendicular at B_1. Then, B_1 is the shadow of the point b' on the **HP**, which has been extended in this case beyond $X\,Y$, as explained in Art. 28. The line $A\,B_1$ will be the shadow of the line $a'\,b'$ on the **HP**. This shadow will cut the line $X\,Y$ at g, so that the portion $g\,B_1$ of the shadow will be on the **VP**, and as it is a continuation of the shadow of the line $a\,b$, and the shadow of the end point b of this line on the **VP** has been found at B, the line $A\,g\,B$ will be the shadow of the line $a\,b$ on the **HP** and the **VP**. The outline of the shadow cast by the cube on the two planes of projection has now been found, and is composed of the lines $c\,D$, $D\,C$, $C\,B$, $B\,g$, $g\,A$, $A\,a$, $a\,b$, $b\,c$.

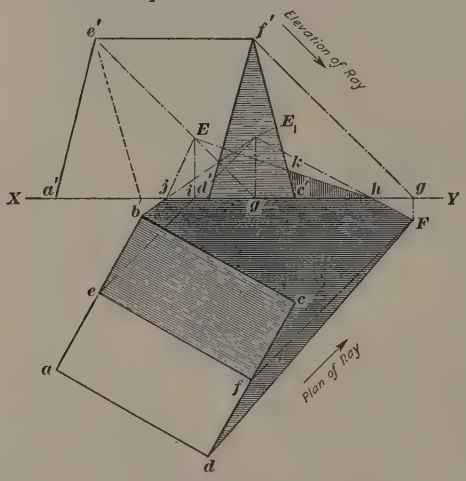


FIG. 21

44. Equilateral Triangular Prism Resting on the HP.—In Fig. 21 is shown at $a\,b\,c\,d$ the plan and at $a'\,e'\,f'\,c'$ the elevation

of an equilateral triangular prism, the shadow cast by which it is required to find. It will be at once observed, by drawing rays from the extreme points b and d of the plan, that the faces $b\,c\,f\,e$ and $d'\,f'\,c'$ are in shade. The shadow cast by the edge $e\,f$ of this prism on the **HP** must first be found, and then, if the extremities of this shadow are joined to the shadows of the outlying corners b and d of the plan, the shadow cast by the prism on the **HP** will be defined.

45. To find the shadow of the edge $e\,f$, draw a ray from f' cutting $X\,Y$ at the point g, and from g drop a line at right angles with $X\,Y$ to cut a ray drawn from f in the point F. The point F will then be the shadow of the point f or f' on the **HP**. From e draw a ray of indefinite length, and from e' draw another ray intersecting the line $X\,Y$ at g, at which point erect a perpendicular cutting the ray drawn from e at E_1. Then, E_1 will be the shadow of e' on the **HP** extended. The line $E_1\,F$ will be the shadow of the ridge $e\,f$ on the **HP**. This shadow cuts the line $X\,Y$ at h, so that the portion $F\,h$ is the only portion on the **HP**, the remainder $h\,E_1$ being on the **VP**.

46. It is therefore necessary to find the position of the shadow of e on the **VP**. At the point i where the line drawn from e cuts the line $X\,Y$ erect a perpendicular to cut the ray from e' at the point E. Then, E is the shadow of e' on the **VP**. Join $E\,h$, when $E\,h\,F$ will be the correct shadow of $e'\,f'$ on the **VP** and **HP**. Join $F\,d$ and $E_1\,b$, and these will be the shadows of the two lines $f\,d$ and $e\,b$ on the **HP**. Part of the shadow of the line $e\,b$ falls on the **VP**, j being the point where the shadow on the **HP** is intercepted by the **VP**. By joining points j and E by the line $j\,E$, the latter line will represent the shadow of $b\,e$ on the **VP**. The area enclosed by $b\,j\,E\,h\,F\,d\,c\,b$ is the shadow of the prism on the **HP** and **VP**, and part of it $j\,E\,k\,c'\,j$ is obscured by the prism itself in elevation.

47. Hexagonal Pyramid Standing on HP.—In Fig. 22 is shown at $a\,b\,c\,d\,e\,f$ the plan of a hexagonal pyramid, whose apex is at g, standing with its axis vertical, on the **HP**. Its elevation is shown at $a'\,g'\,d'$. In this case is found the shadow of its apex g on the **HP** produced, and this point joined to

the outermost corners of the base will limit the shadow of the pyramid on the **HP** and also determine which faces are in shade. From g' draw a ray cutting $X\,Y$ at the point h, and from h draw a line of indefinite length at right angles to $X\,Y$. From g, the plan of the point g', draw a ray to cut the vertical from h at G_1. Join G_1, b and G_1, d, then the area $b\,G_1\,d\,c\,b$ defines the shadow of the pyramid on the **HP**. This shadow is cut by the **VP** at the line $X\,Y$, hence a part of it will rest on the **VP**. The portion of the shadow $i\;G_1\;j$ is the portion that

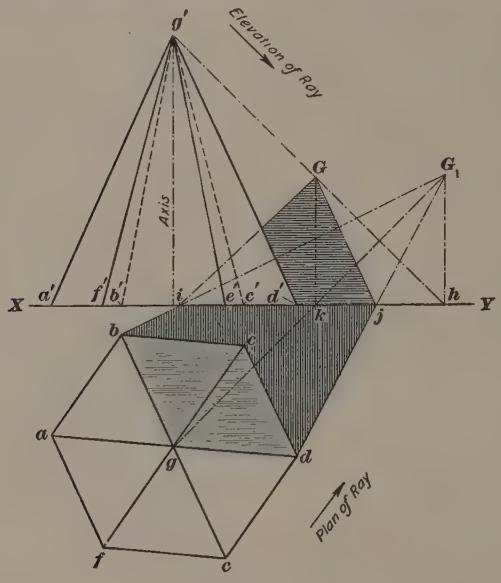


FIG. 22

will rest on the **VP**. To find its position, draw from k, the point where the ray from the point g cuts $X\,Y$, a line $k\,G$ at right angles to $X\,Y$ cutting the ray from g' at G. Then, G will be the shadow of the point g' on the **VP**. Lines joining G, i and G, j will outline the shadow of the pyramid on the **VP**, and the shadow on both planes will be that contained within the lines $b\,i$, $i\,G$, $G\,j$, $j\,d$, $d\,c$, and $c\,b$. It will be seen that the faces $g\,b\,c$ and $g\,c\,d$ of the pyramid are in shade.

48. Cone Standing on HP.—Fig. 23 shows the plan and elevation of a cone, whose axis is vertical, standing on the **HP**. In a similar manner to the problem in Art. **47**, the shadow of its apex a on the **HP** produced must be found. From a' draw a ray cutting $X\,Y$ at the point b, from which point draw a line of indefinite length at right angles to $X\,Y$. From a in the plan draw a ray intersecting the vertical line drawn from b at A_1. Then, A_1 is the shadow of a on the **HP** produced. From A_1

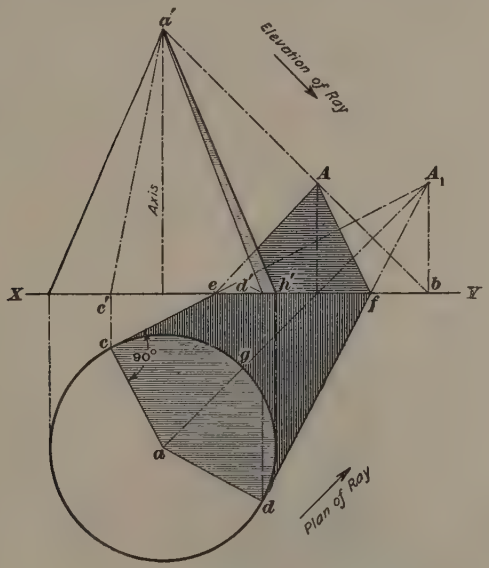


Fig. 23

draw lines $c\,A_1$ and $d\,A_1$ tangent to the base of the cone at the points c and d.

Find the elevation on the **VP** of the point a', which is the apex of the cone, in a similar manner to that described for the pyramid in Fig. 22, and join the point A, so found, to e and f, the points where the lines bounding the shadow on the **HP** cut $X\,Y$. Then, the shadow of the cone cast on the **HP** and **VP** is the area bounded by $c\ e\ A\ f\ d\ g\ c$.

49. To find the shade line on the surface of the cone, or the line that is dividing the surface of the cone into spaces of light and shade, draw from the points c and d lines $c\,a$ and $d\,a$ to a, the plan of the apex of the cone. Then, the surface of the cone contained within the space c, g, d, a, c will be in shade, while the portion of the surface opposite to this space will be in light, the dividing or *shade line* between the two being the line $c\,a\,d$. To find the elevation of this shade line, project the points c and d to the elevation at c' and d' and join points c' and d' with a'. The portion $d'\,h'\,c'\,a'\,d'$ of the surface of the cone in elevation will be in shade, of which only the portion $d'\,a'\,h'$ is visible in the elevation.

Although, of course, there is no sharply defined line between light and shade in nature, yet before any artistic rendering of surface shading is attempted the actual boundaries of the shades must be found. It is the aim of this Section simply to give instruction in the methods of finding the boundaries of shade and shadow.

50. Cylinder Standing on HP, Axis Vertical. — Let $a'\,b'\,c'\,d'$, Fig. 24, be the elevation of a cylinder whose plan has its centre at e. If rays are drawn tangent to the plan of the cylinder, the points f and g indicate the positions of the shade lines. By projecting these points to the elevation, the points f', h', g', i' will indicate the positions of the shade lines in this view. The shadow cast by the cylinder will be bounded by the shadows of the

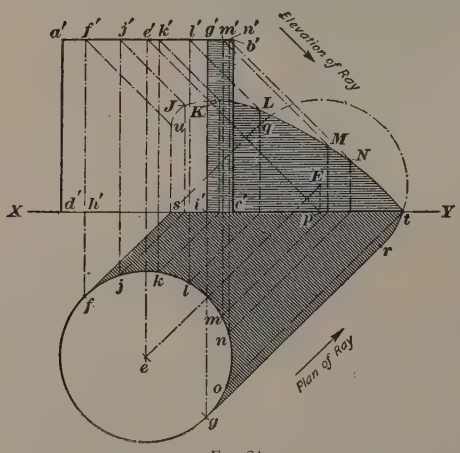


FIG. 24

vertical shade lines $f'h'$ and $g'i'$ and by the shadow of the semicircle $f\,j\,k\,l\,m\,n\,o\,g$. To ascertain the shadow of the cylinder, it is preferable first to find the shadow thrown on the **HP**, extending the latter, if necessary. The simplest way to do this is to find the shadow of the point e or the centre of the circle. From e' draw a ray cutting $X\,Y$ at p, at which point erect a perpendicular of indefinite length. From e draw a ray cutting this perpendicular at E, which will be the shadow of the centre e of the circle on the **HP**. With E as a centre, draw a semicircle of the same radius as the plan of the cylinder, joining the lines drawn from f and g at q and r. The shadows of these lines cut $X\,Y$ at s and t, so that the portion of the shadow $s\,q\,t$ must be projected on to the **VP**. From s draw a line at right angles to $X\,Y$ until it cuts a ray drawn from f' at u. Then, $f\,s\,u$ will be the shadow of the shade line $h'f'$ on the **HP** and the **VP**.

51. The part $r\,t$ of the shadow thrown on the **HP** is part of the semicircular top. To find the point on the top that corresponds to the point t, draw a ray through this point intersecting the semicircle in **HP** at o. This will be the point producing the shadow t. To ascertain the outline of the remaining part of the shadow thrown on the **VP**, it is necessary to subdivide the curve $f\,o$ in the plan into a number of parts as $f\,j$, $j\,k$, etc. Project the points j, k, etc., to the elevation of the curve, thereby finding the points j', k', etc. Draw rays from the points j, k, etc., in **HP**, and from their points of intersection with $X\,Y$ erect perpendiculars of indefinite lengths. By drawing rays from the points j', k', etc., in **VP** so as to intersect the perpendiculars at the points J, K, etc., these points will define the outline of the shadow in **VP**. By connecting these points by a curved line, the shadow thrown by the semicircle $f\,l\,o$ on the **VP** will be found.

SHADOWS OF COMBINED SOLIDS

52. Square Slab on Top of Prism.—The problem contained in Fig. 25 is very similar to some of those previously given, and is simply a combination of some of the problems already

solved. Instead of finding only the shadow cast on the **HP** and the **VP**, there is to be found the shadow cast by the slab on the prism. Let *a b c d* be the plan of a square slab shown in elevation at *d′ c′ i′ j′* resting on the rectangular prism *e f g h*,

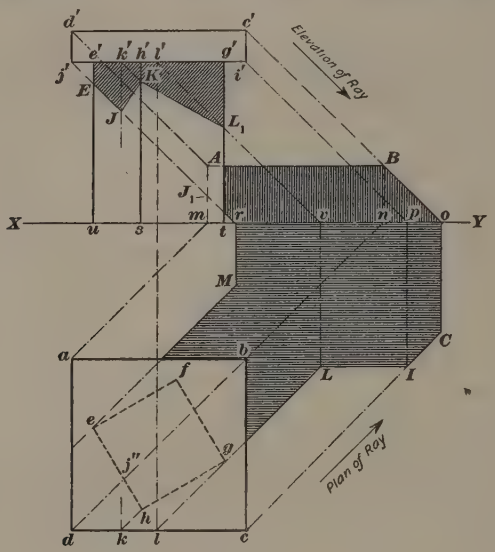


Fig. 25

which in turn stands vertically on the **HP**. To find the shadow of this combination on the **HP** and **VP**, it is simply necessary to find the shadow of the shade lines, as before described.

53. First, find the shadow cast by the slab on to the prism by drawing a ray from *d*, meeting the face *e h* at *j″*. Project this point vertically until it cuts a ray drawn from *j′* at the point *J*. From *h* on plan draw a ray *h k* cutting *d c* at *k*. Project this point to the **VP**, intersecting *i′ j′* at point *k′*. A ray drawn from *k′* will intersect the edge *h′ s* at *K*, which point will be one of the points in the shadow thrown on the prism. In a similar manner, draw a ray from *g* to cut *d c* at *l*. Project this point so as to give the point *l′* in the elevation and draw

a ray from l' intersecting $g'\,t$ at L_1, which is another point in the shadow. Join K, L_1. The point E at the other end of the shadow is found by simply drawing a ray from the point j' in **VP** intersecting the edge $e'\,u$ at E. The shadow cast by the slab on to the prism is now completely defined.

54. The shadow cast by the slab and prism on to the **HP** and **VP** has now to be found. From a draw a ray cutting $X\,Y$ at m, and erect a perpendicular cutting a ray drawn from d' at A. Then, A is the shadow on the **VP** of the point a. To find the shadow of the edge of the slab of which a is the topmost point, and which coincides in elevation with the line $d'\,j'$, draw a ray from j' cutting A at J_1. Then, $A\,J_1$ is the shadow on the **VP** required. At n, the point on $X\,Y$ where a ray drawn from b cuts it, erect a perpendicular to cut a ray drawn from c' in B. The line $B\,A$ is the shadow of the line $b\,a$ on the **VP**.

55. As the line $b\,c$ is at right angles to **VP**, its shadow will incline at an angle of 45° with $X\,Y$. Therefore, continue the ray through B until it intersects $X\,Y$ at o, at which point drop a perpendicular to cut a ray drawn from c at C. Then, $B\,o\,C$ is the shadow of the edge $b\,c$ of the slab on the **VP** and the **HP**. From i' draw a ray cutting $X\,Y$ at p, from which point drop a perpendicular to cut at I the ray drawn from c. Then, $C\,I$ is the shadow of $c'\,i'$ on the **HP**. It will be seen from the plan that a portion $l\,c$ of the lower edge of the slab under and parallel with $d\,c$, and represented in elevation by $l'\,i'$, casts its shadow on the **HP**, and a portion $d\,l$, as has already been found, casts its shadow on the prism at J, K, L_1. To find the shadow of the line $l'\,i'$ on the **HP**, it will be necessary to find the shadow of l' only, as the shadow of the point i' has already been found at I. Produce the ray through g until it intersects at L a vertical from point v, the latter point being one where a ray from l' intersects $X\,Y$. The line $I\,L$ will be the shadow of $i'\,l'$ on the **HP**.

The ray drawn from g cutting $I\,L$ at L, or $g\,L$, is the shadow of the portion of the edge of the prism whose plan is shown at g on the **HP**. In a similar manner, the shadow of the edge of the prism whose plan is at e may be found, and the

shadow of the object may be completed by drawing from J_1 a ray at an angle of 45° with $X\,Y$ to meet it in r, and from that point dropping a perpendicular to meet the ray drawn from e at M. The outline of the shadow of the slab standing on the prism as it is cast on the **HP** and **VP** is now complete, and its outline is $e\,M\,r\,J_1\,A\,B\,o\,C\,I\,L\,g\,f\,e$, part of which is hidden by the plan and elevation of the object.

56. Fig. 26 is a perspective view of the object shown in Fig. 25. Some of the construction lines have here been omitted

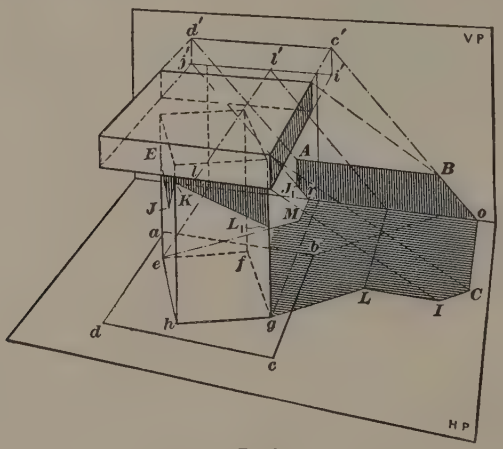


Fig. 26

for the purpose of clearness, but otherwise similar letters indicate similar points. The main purpose of this view is to show the relation between the shadow and the parts of the object producing corresponding parts of the shadow. A series of rays has therefore been shown as passing from the more important points of the object to the shadow itself.

57. Square Abacus on Top of Short Fluted Column.—It is required to find only the shadow cast by the abacus $a'\,b'\,c'\,d'$, Fig. 27, upon the fluted column whose centre in the plan is shown at e. The line of shade is also to be found. As the

cast shadow of this object on the **HP** and **VP** is found in a manner very similar to that explained with reference to Fig. 25, it is not necessary to repeat this construction. To find the line of shade, draw a ray so as to pass through point *f*. As this ray in the present case also is tangential to the column at point *g*, it follows that the two edges in the **VP** that correspond to these points will be the boundary lines of a shaded surface, and the parts in the rear of point *f* will likewise be in shade.

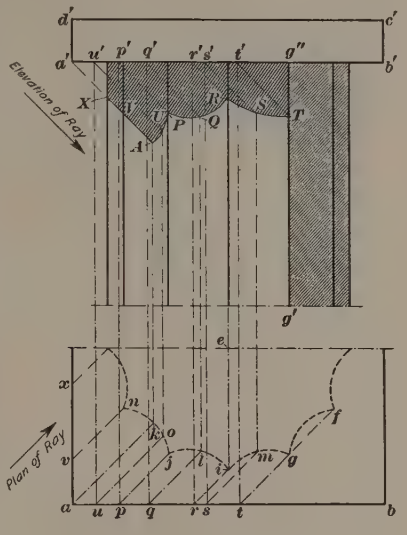


Fig. 27

58. It is evident from Fig. 27 that only the lower edges of the abacus will cast a shadow on the fluted column. A number of points on the line *a b* are selected through which rays will be passed for the purpose of outlining the shadow. For convenience' sake, it is preferable to select such points that the rays through them will meet the edges of the column, such as *f*, *g*, etc. Rays drawn from such points intersect line *a b* at *t*, *s*, etc. The latter points are projected to line *a' b'* in the **VP**. As the remaining part of the construction is similar to that shown in Fig. 25, it will suffice to find one point only. For instance, the ray through point *g* intersects line *a b* at *t*. The latter point projected to the **VP** gives *t'*, and a ray through this point intersects the edge *g' g''* at *T*. Other points selected for projection are the centre points of the recesses, such as *k*, *l*, and *m*. The complete outline of the shadow is defined by the letters *X V A U P Q R S T*.

59. Cylinder With Square Slab on Top.—In Fig. 28 are shown the plan and elevation of a cylinder supporting a square slab.

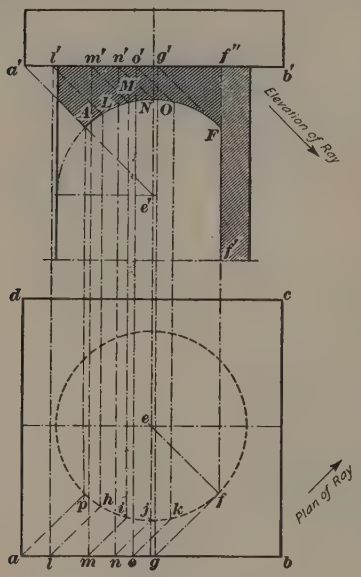


FIG. 28

As shown in **HP**, the centres of the slab and cylinder coincide at the point *e*. The edge casting the shadow on the cylinder is indicated by line *a b*, shown in elevation at *a' b'*.

The shade line of the cylinder is found in a manner similar to that described for Fig. 24 by drawing rays tangential to the plan of the cylinder, as at *f*. This point projected to the elevation will be represented by the line *f' f''*, which is the shade line. Produce the ray through *f* until it cuts *a b* at *g*, and project *g* to *g'* in the elevation and draw a ray from this point cutting the shade line at *F*. Then, *F* will be the point where the shade line will be cut by the cast shadow from the slab. To find the shadow cast by the slab or by the line *a' b'*, draw from *a* a ray cutting the face of the cylinder at *p*, and from *a'* draw a similar ray to cut a perpendicular run up from *p* at *A*. Then, *A* is the shadow of the point *a'* on the cylinder. Take any number of points *h*, *i*, *j*, *k* between *p* and *f* on the face of the plan of the cylinder, and draw through these points rays to cut *a b* in *l*, *m*, *n*, and *o*. Project these points to the elevation, as at *l'*, *m'*, *n'*, and *o'*, and draw from them rays to cut lines run up from *h*, *i*, *j*, and *k*, thus obtaining the points *L*, *M*, *N*, *O*, *F* of the shadow.

60. It will be seen that the curve *A L M N O F* is a circular arc of the same radius as *e f* of the cylinder, so that if the centre

of the arc could have been found on the elevation the time taken in finding and projecting the various points p, h, i, j, k, f could have been saved. In this case it is found that a ray drawn through the point a cuts the centre e of the plan of the cylinder, so that if in the elevation a ray is drawn through a' it will cut the axis of the cylinder in e', which will give the centre from which the arc may be struck in elevation. A rule applicable to similar cases is as follows: *The distance, in the elevation, between the centre of the arc and the line casting the shadow is always equal to the distance in the plan between the corresponding line and the centre of the cylinder on to which the shadow is cast.* In the case shown in Fig. 25, the distance between e' and $a'\ b'$ could at once have been determined by making it equal to $e\,g$.

SHADOWS ON ARCHITECTURAL DETAILS

61. Niche, Semicircular on Plan.—In Fig. 29 is shown the plan and elevation of a niche which has a semicircular head and is semicircular in plan. It is evident that the edge $d'\ a'\ b'\ l'$. made by the intersection of the curved face of the niche and the wall face in which it is situated, is the edge that will cast the shadow. Take any number of points as a', b', c' on this edge, and project them to the plan, as at a, b, c. Rays drawn from a, b, c to cut the wall face of the niche at a'', b'', c'' and projected to the elevation to cut rays drawn from a', b', c' will give the points A, B, C, which are the shadows of the points a', b', c' on the wall face of the niche in elevation. It is evident that the vertical edge $a'\ d'$ will cast a vertical shadow line on the wall face of the niche, and as the shadow of a' has been found at A, a vertical line drawn through A to D will complete the shadow of $a'\ d'$ on the wall face of the niche.

The points D, A, B, C have been found quite easily, as the plan of the niche up to the springing line $a'\ e'$ curves only in one direction. Above the springing line it will be seen that the niche curves both ways, so that a different method must be used for obtaining the shadow above the springing line. As the head of the niche is a semicircle, the termination of the shadow will be at a point F, a point of tangency of a ray.

62. To find the outline of the shadow on the head of the niche, it is necessary to make a series of imaginary sections by means of planes perpendicular to **HP** and 45° to **VP**, as indicated by lines $g\,g''$ and $h\,h''$. The greater the number of sections taken the more accurate will the defined shadow be. The lines of intersection between these planes and the niche are found by means of a series of horizontal planes intersecting the niche at different levels. These planes are indicated in **VP** by the lines $a'\,e'$, $i'\,j'$, etc. The lines of intersection between these planes and the head of the niche must be projected to **HP** in the following manner: The plane $i'\,j'$ intersects the niche at the points i' and j' in the **VP**; therefore, project the point j' to the line $a\,e$ in **HP**, thus finding the point j''. Evidently the line of intersection between the plane $i'\,j'$ and the niche must be a semicircle with a radius $g\,j''$. Describing this semicircle it will intersect the plane $g\,g''$ at p. If this point is projected to the plane $i'\,j'$, the point p' will be found. The point k' projected to $a\,e$ gives the point k''. An arc with radius $g\,k''$ intersects the plane $h\,h''$ giving point H. Proceeding similarly with the other planes, their lines of intersection with the niche will be defined in the **HP** by the arcs $k''\,o$ and $m''\,n$.

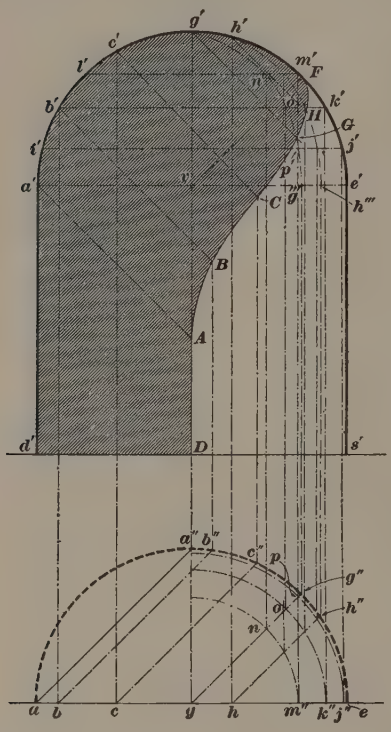


Fig. 29

63. The points at which these arcs intersect lines $g\,g''$ and $h\,h''$ are projected to the corresponding planes in **VP**; for instance, point n is projected to point n' on line $l'\,m'$, point o to o' on line $b'\,k'$, etc. On connecting the points g', n', o', p', and g''', the resulting curve $g'\,n'\,o'\,p'\,g'''$ will represent the line of intersection between the plane $g\,g''$ and the niche. Proceeding in the same manner with the other plane $h\,h''$, similar points will be found on the curve $h'\,h'''$. The purpose of inclining the intersecting planes $g\,g''$ and $h\,h''$ at an angle of 45° to **VP** is that they may serve as a means for finding the points where those rays that touch the head of the niche will meet its inner surface. Evidently some of the rays must lie in the planes $g\,g''$ and $h\,h''$. For instance, if a ray passes through point g in **HP**, its direction in **VP** will be indicated by the line $g'\,G$. The point where it cuts the curve $g'\,g'''$ will be the shadow of point g. Similarly, the shadow of h will be at H in the curve $h\,h'''$. A line $v\,F$ drawn from the centre v at an angle of 45° to the horizon will cut the niche at point F; the rays at this point will be tangential to the edge of the niche, and no shadow will be produced below and to the right of this point. Hence, the point F will represent the upper end of the shadow. The line $F\,H\,G\,C\,B\,A\,D$ will therefore be the shadow line of the niche. A shadow will also be thrown by the edge $a'\,d'$ on the horizontal surface $d'\,s'$ of the niche, as indicated by the line $a\,a''$ in **HP**. It is to be noted that, for the purpose of making the drawing clearer, the wall above the plan of the niche has not been shown in section.

64. Shade Line on an Abacus.—The plan and elevation of an abacus are shown in Fig. 30 at (*a*) and (*b*). It is required to find its shade line. There are several methods by which this may be done; the method of sections used in Fig. 29 may be applied, or one somewhat simpler, shown in Fig. 30, may be used. In the latter case, an elevation is made of the abacus on a plane parallel to the line $x\,y$, as at (*c*), Fig. 30. When seen in this position, the shade line will be a straight line $N_1\,A_1\,E_1$, Fig. 30 (*c*), but to ascertain the positions of the two extreme points E_1 and N_1 rays of 45° inclination cannot be used. This

will be evident from Fig. 1, where the diagonal $d\,f$ corresponds to the position of the line $x_1\ y_1$ in Fig. 30 (*c*). The light rays will therefore have an inclination of 35° 16′ toward the centre

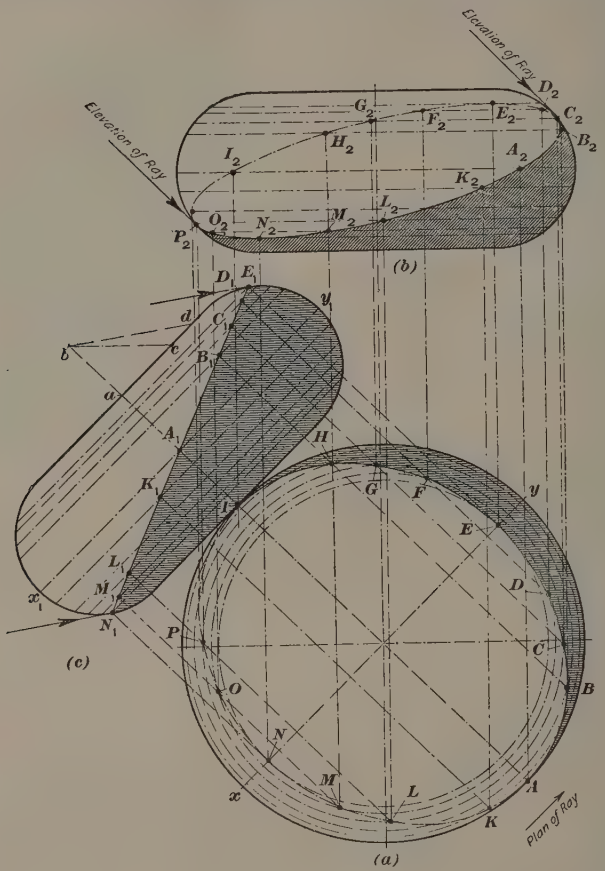


FIG. 30

line $x_1\ y_1$. This inclination may be quickly found by the method shown in view (*c*), where $a\,b$ represents a line of any convenient length, drawn at right angles to $a\,d$. Make $a\,c = a\,b$, and $a\,d = b\,c$. Then, $b\,d\,a$ will be the required angle of

35° 16′. Draw rays parallel to $b\ d$ tangential to points E_1 and N_1, and $N_1\ E_1$ will be shade line of the abacus.

65. A plan view of the shade line may be found by intersecting the abacus by a series of planes parallel to its base. By projecting to the plan view the points of intersection between the planes and the shade line, the position of the latter may be outlined in the plan. In view (*c*), intersecting planes have been drawn through the points N_1, M_1, L_1, K_1, A_1, B_1, C_1, D_1, and E_1. After plan views have been made of these planes by drawing the circles shown in dash-and-dot lines, the points N_1, M_1, etc., are projected to the plan giving the points N, M, etc., on the shade lines. The part $A\ E\ I$ is visible, but the remainder $A\ N\ I$ is below the side of the abacus, and is therefore shown by a dash-and-dot line.

66. The plan view of the shade line must now be projected to the elevation at (*b*). This construction is in reality equivalent to revolving the abacus, shown at (*c*), through an angle of 45°, it being assumed that the shade line revolves with the abacus. The new position of the shade line could therefore easily have been drawn in view (*c*), but to avoid an increase in the number of lines, the construction is shown separately at (*b*). The same number of intersecting planes, similarly placed, are inserted in the latter view to which the points in view (*a*) are projected, thus fixing the positions of points P_2, O_2, N_2, etc. Also here part of the shade line is invisible, which is indicated by the line $C_2\ D_2\ \ldots\ P_2$. It is seen at once that the point A_1 in view (*c*) has been moved into the position A_2, view (*b*), through an angle of 45°, and all the other points have performed a similar motion. The rays, shown in view (*b*), have the regular inclination of 45°.

67. Head of Column With Circular Abacus.—In Fig. 31 are shown the plan (*a*) and elevation (*b*) of a column with a circular abacus. The proportions of the latter, relative to the column, have in this example been exaggerated for the purpose of bringing the required construction lines farther apart. The abacus is the same as that shown in Fig. 30, and similar points of projection

have been used. It is assumed that the shade line of the abacus has already been found by the method described, and all that is required is therefore to find its shadow on the fillet $o_2\, p_2\, g_1$ of the column, and finally to find the shadow of the fillet on the column proper.

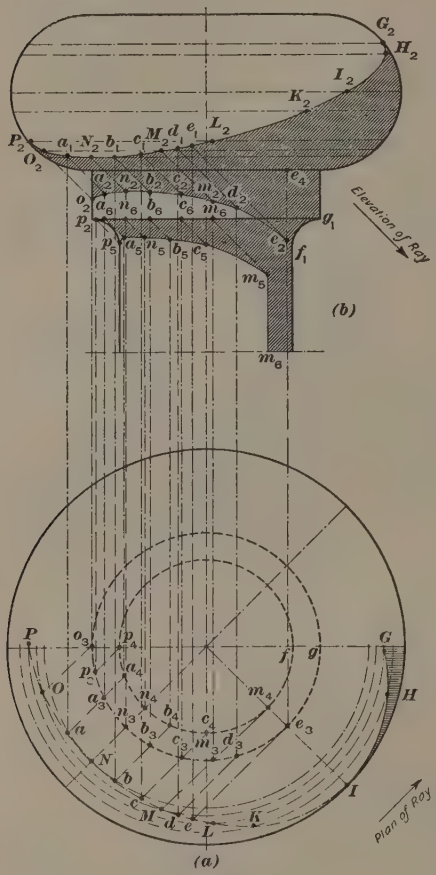


Fig. 31

It is evident that the shade line of the abacus must be the line that produces the lower border line of the shadow; hence, rays proceeding from the shade line, as shown in the plan and elevation, must be the means by which to find the outline of the shadow. The circle with diameter $o_3\, g$ is a plan of the fillet $p_2\, g_1$, and the circle with diameter $p_4 f$ is the plan of the column shaft $p_5\, f_1$.

68. As o_3 is the extreme point of the visible part of the fillet, project a ray from it intersecting the shade line at O, and project the latter point to O_2 on the shade line in the elevation. A ray from O_2 intersects the outline of the fillet at o_2, which point is

on the outline of the fillet shadow. Select another point, such as a on the shade line, and project a ray intersecting fillet and column at points a_3, a_4. Project a to a_1 on the shade line in elevation, and from it draw a ray intersecting a vertical from a_3 at a_2. Then, a_2 is another point on the shadow outline. From a_6, where line $a_2\ a_3$ intersects the lower edge of $p_2\ g_1$ of the fillet, draw a ray intersecting a vertical from a_4 at a_5. The latter point is on the shadow thrown by the fillet on to the column. The extreme point of the latter shadow is found by drawing a ray from p_4 to p_3, and from the latter point a vertical intersecting the fillet at p_2. A ray drawn from the latter point toward the column intersects it at p_5, which is the extreme point of this shadow. The other points n_5, b_5, and c_5 are found in a similar manner. To find the extreme point m_5, draw a ray from m_4 to cut the plan of the fillet at m_3. Project m_3 to the elevation at m_6, and draw a ray from the latter point cutting the shade line at m_5, the point required.

69. The shade line of the fillet is found by drawing a ray tangent from point e_3 to e and projecting e to e_1, and then from here a ray intersecting a vertical from e_3 at e_2. The vertical $e_2\ e_4$ is the shade line of the fillet, the point e_2 in this case falling below the fillet and the shade line otherwise being hidden by the shadow from the abacus. The shade line on the column is found in a similar manner by drawing a ray tangential to it at m_4 and projecting this point to m_6 in the elevation; then, $m_5\ m_6$ is the shade line of the column.

70. Cornice Projecting From a Wall.—In Fig. 32 (a) is shown the plan, and at (b) the elevation, of a moulded cornice projecting from a wall. It is required to find the shade lines and shadows cast by the various members of the cornice on the cornice itself, and also to find the shadow cast by the cornice on to the wall. In (a), $X\ Y$ is the face of the wall against which the cornice is built and on which the projection of its shadow is to be cast. It is preferable first to find the shade and shadow lines on the cornice itself, and as the return portion of the cornice $a\ b$, which is at right angles to the wall face $X\ Y$, is of the same section as the main or front portion, the depth of the shadow of the various

members can be at once determined by rays drawn through the different outlying corners of the profile, as at a', f', g'.

It is noticed that the rays from a' and other points in view (b) are drawn in a direction reverse from that hitherto used. The reason for this is that, the left-hand side of the cornice being omitted, the other side has to be used in its place for finding

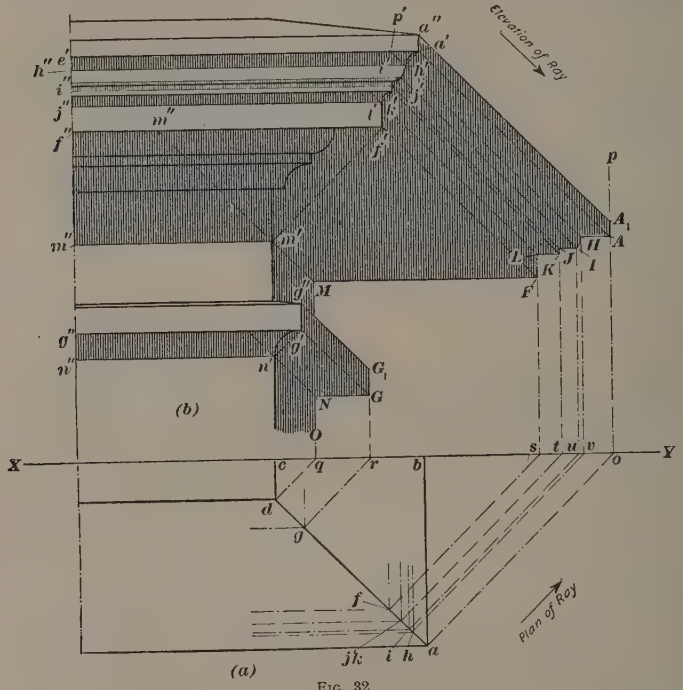


FIG. 32

the shades and shadows. It is evident that the lines indicating the lower boundary lines of the various shadows can be found by using either side of the cornice, but if the right-hand side is used, as in this case, the directions of the rays must of necessity be reversed.

71. A ray drawn from a', in view (b), cuts the face of the curved moulding at h'; the drawing of a horizontal $h'\,h''$ gives

the position of the boundary line of the shadow of the edge $a'\ e'$ on the face of moulding underneath. The shade line of this moulding is found by drawing a ray tangent to it at i'; the line $i'\ i''$ is then the upper side of the shade line. The lower side of the shadow cast by this moulding on the vertical faced fillet beneath is found by drawing the line $j'\ j''$ through the point where the ray from i' intersects this surface. In a similar manner, draw a ray from point k' to the vertical face below, intersecting it at l'. A horizontal through l' gives the lower boundary line of the shadow thrown on this surface.

72. A ray from f' will intersect the cornice at m'; the horizontal $m'\ m''$ is therefore the shadow of line $f'\ f''$, and all the intermediate parts are in shadow because inside of the ray $f'\ m'$. The shadow of the remaining edge $g'\ g''$ at $n'\ n''$ is found in a similar manner.

If the preceding part of this Section has been thoroughly understood, there will be no difficulty in finding the shadow of the cornice on the wall. For instance, the shadow of point a'' is found by drawing a ray from a intersecting the line $X\ Y$ at o, at which point a vertical $o\ p$ is drawn intersecting a ray from a'' at A_1. Evidently the shadow of point a' must lie on the line $o\ p$, its position being at A, the point where a ray from a' intersects $o\ p$. It is evident from view (b) that a part of the edge $a'\ e'$ must throw a shadow on the wall. The extent of this shadow is found by drawing a ray from h' intersecting $a'\ e'$ at p'. If the ray is produced in the other direction it will cut at H a horizontal through A; the line $A\ H$ is therefore the shadow of the edge $a'\ p'$. A check on the correct position of this point is made by drawing a ray from h intersecting $X\ Y$ at v, where a vertical is erected intersecting $A\ H$ at H. At H begins the shadow of the curved moulding $h'\ i'$, terminating at I, this point being a point of intersection between a ray from i' and a vertical $u\ I$, drawn from u where a ray from i cuts $X\ Y$.

73. It is evident that the points that determine the boundary lines of the shadow on the wall are points situated on the cornice on the boundary lines between light and shade, such as a'', a', h', i', etc. If, therefore, rays are drawn from these points

in view (*b*), and from corresponding points in view (*a*), and also verticals from the points of intersection of the rays in view (*a*) with $X\,Y$, then the points where these verticals cut the rays drawn from points in (*b*) will give the points that define the shadow outline on the wall. These points define the outline of the shadow, as $A_1\,A\,H\,I\,J\,K\,L\,F\,M\,G_1\,G\,N\,O$. In comparing the outline of this shadow with the profile of the cornice, it is seen that the shaded parts of the latter throw no shadows on the wall. For instance, the mouldings between f' and m' are

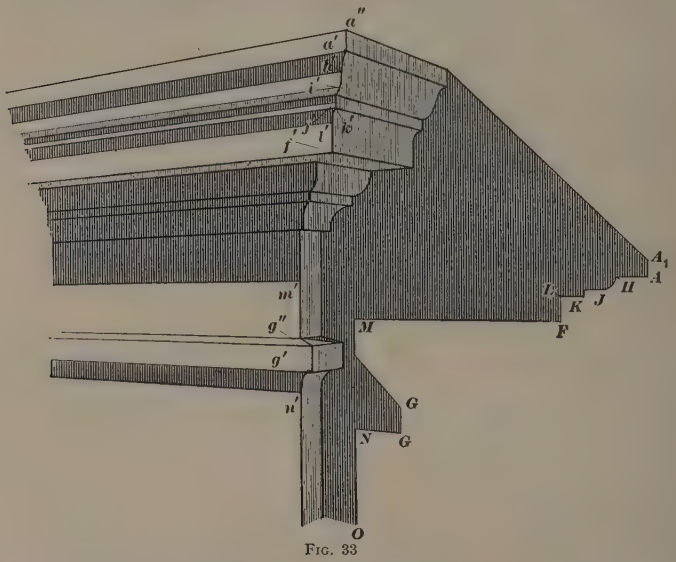


FIG. 33

not seen in the shadow, they being represented by the line $F\,M$, which is a shadow of the edge $f'\,m''$. Similarly, the curve $g'\,n'$ is not shown in shadow for the same reason.

In Fig. 33, the cornice with its shadow are shown in perspective. This view shows clearly the depths of the various parts of the cornice, and likewise the parts situated in the shade and not shown in Fig. 32.

74. Shadow of a Column on a String-Course.—In Fig. 34 (*a*) and (*b*) are shown the plan and elevation of a vertical cylinder

or column *a* standing in front of a wall *b c*, on which is a string-course moulding. A section through the wall and string-course is shown at (*c*). By drawing rays tangent to the plan *a* of the cylinder at *d*, *e* to cut the wall face at the points *f*, *g*, the boundary lines of the shadow cast by the column or cylinder on the wall

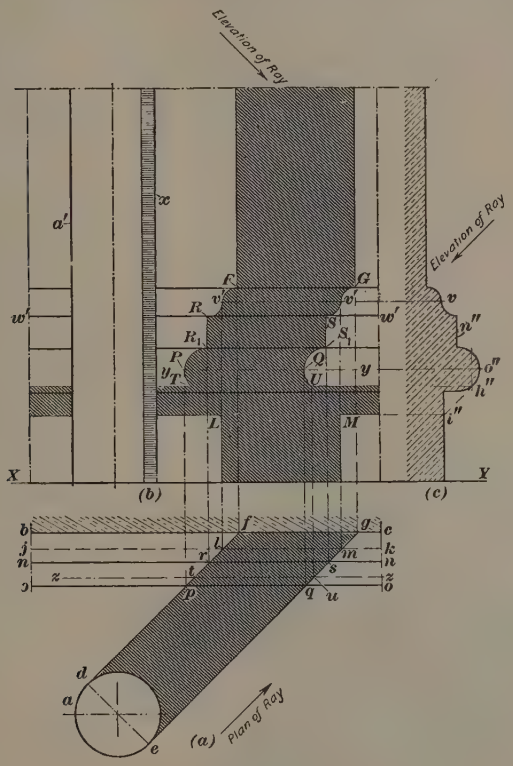


Fig. 34

above the string-course will be found. The points *d* and *e* will also give the positions of the shade lines of the column itself by projecting them, as shown. Only one is necessary, however, that through *e*, for the one through *d* is behind the column and will not be seen in elevation.

75. To complete the shadow of the column on the string-course and the shadow of the string-course on the wall, as also the boundary lines of the shadow on the string-course in plan and on the **HP**, project the points f, g to points F, G in the elevation above the string-course, and the boundary lines of the shadow cast by the column on to the wall face above the string-course will be obtained by verticals through these points. Draw a ray tangent to the curved moulding at h'' in view (c) cutting the wall face below the string-course at i''. A line drawn through h'' on to the elevation will give the shade line on the moulding, and a line drawn through i'' in a similar way will give the boundary of the shadow cast by the moulding on to the wall. To find the boundary lines of the shadow cast by the column on to the wall face below the string-course, which from the section (c) is seen to stand in front of the general wall face above the string-course, draw the line $j\ k$ in (a) to indicate the position of the face in which i'' is situated in the plan. The rays $d\ f$ and $e\ g$ cut $j\ k$ at l and m. Project l and m to the elevation to cut the horizontal shadow line drawn through i'' in view (c) at the points L and M. Then the shadow on the wall face below the string-course will be complete, and only the shadow of the column on the string-course is yet to be found.

76. The plan of the string-course, shown at (a), is indicated by the lines $o\ o$ and $n\ n$, which lines represent the faces o'' and n'' in view (c). The points where the rays $d\ f$ and $e\ g$ meet these faces are p, q, r, and s. The points F and G have already been found, and the position of the column shadow on the face n'' can be ascertained by projecting points r and s in view (a) to the edge $w'\ w'$ in the elevation, thus fixing points R and S. Verticals $R\ R_1$ and $S\ S_1$ indicate the boundary lines of the shadow on the vertical face.

The curves $F\ R$ and $G\ S$, indicating the part of the shadow that falls on the moulding v, may be defined by a number of points, depending on the accuracy required. In this instance, only one point besides the end points is fixed. An imaginary section is made by means of a horizontal plane along the line $v'\ v'$ in the elevation. The line of intersection with the moulding

coincides in the plan with the line $j\ k$. The points l and m are therefore projected to line $v'\ v'$, giving the points v', v' on the shadow. The remainder of the curves $F\ v'\ R$ and $G\ v'\ S$ has in this instance been drawn by freehand. If greater accuracy is required, the number of intersecting planes must be increased.

77. The boundary of the shadow from the column on the lower curved part o'' of the string-course, view (c), is shown at points p and q in (a). A plane $y\ y$ intersecting the moulding o'' through its centre, as shown in (b), will have its line of intersection coincide with $o\ o$ in view (a). The points p, q projected to line $y\ y$ will give points P, Q on the shadow boundary. It is necessary to find the junction between this shadow and the shade line of the member o''. For this purpose it is necessary to indicate the position of this shade line in the plan (a) by means of the line $z\ z$. The distance between this line and line $o\ o$ is equal to the horizontal distance between h'' and o'', as found in view (c). The rays $d\ f$ and $e\ g$ intersect line $z\ z$ at t and u. By projecting these points up to the shade line in view (b), the points T and U are found. By completing the curves $R_1\ P\ T$ and $S_1\ Q\ U$ the shadow cast by the column will be complete.

FIG. 35

78. In Fig. 35, the elevation shown in Fig. 34 (b) is provided with surface shading. While the outlines of the shadows are exactly the same in both views, there is some difference between the shade lines. For instance, it is noted that in Fig. 34 (b) the shade on the column a' is of even density up to the border line x. In Fig. 35, the shade is here lighter, due to reflected light from the wall surface b. In a similar manner light will be reflected

from the surface *c* to the lower side *d* of the string-course. Likewise, the shade line on the column is not sharply defined, as in Fig. 34, but grows gradually lighter until it reaches the area of highest light. The shadow thrown on the member *d* is somewhat lighter at its upper and lower boundary lines and its side lines are not sharply defined, but fade gradually off into the shade on the under side. The introduction of reflected light, as here shown, contributes largely to give a better idea of receding surfaces and such that are situated at different distances from the observer. This is seen at once by comparing Figs. 34 and 35. As a guide in shading drawings, every opportunity should be utilized in analyzing the methods employed by experienced architects in their drawings. It is also advisable to study the shadows of familiar objects, noting the effects of reflected light and the gradual change from shade to light.

79. Semicircular Arch on Corbels.—In Fig. 36 at (*a*) is shown the elevation of a semicircular arch recessed in a wall and built on corbels, and at (*b*) is shown the section through the centre

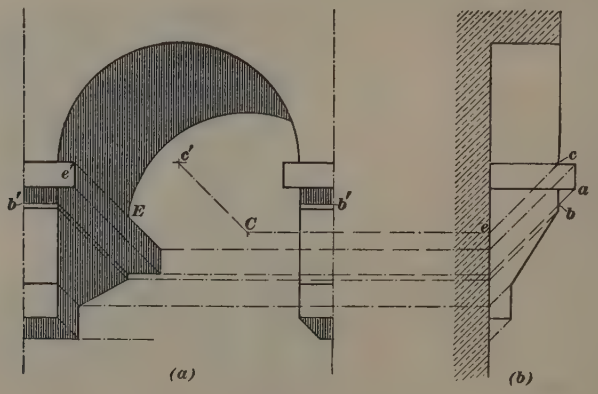


FIG. 36

point of the arch. It is required to find the shadow cast on the wall face and on the corbels. The depth of the shadow cast by the cap of the corbel on to the corbel will be found by

drawing a ray from *a* in view (*b*) until it cuts the face of the corbel at *b*, and then projecting this point to the points *b'* in the elevation (*a*). Horizontals through points *b'* will be the lower boundary of the shadows on the corbels. The shadow of the corbel on the wall can be found in a similar manner to that described for the cornice in Art. **72,** by drawing rays from the various points in view (*b*) so as to intersect the wall face at the back. If horizontal lines are drawn from the points of intersection to the elevation, or so as to cut rays drawn from similar points in the elevation, these points of intersection will be points in the boundary lines of the shadow.

80. According to Art. **32,** the shadow cast by the semicircular arch on the wall will be of the same outline as the arch itself, so that it is necessary to find only the shadow of the centre *c'* of the arch in (*a*). This centre is supposed to be in the plane of the face of the arch, as at *c* in (*b*). Through *c* draw a ray until it cuts the wall face at *e*, and draw a projector through the point *e* horizontally across to the elevation until it is cut at the point *C* by a ray drawn through *c'*. Then, *C* is the shadow of the centre of the arch. With *C* as centre, and radius equal to the radius of the arch, draw the curve of the outline of the shadow until it meets at *E* the ray drawn from *e'*, the corner of the cap. The other parts of the shadow are found in the manner previously described, and no further explanation is necessary.

81. Chimney Stack in a Sloping Roof.—At (*a*) in Fig. 37 is shown the elevation and in (*b*) the side elevation of a chimney stack projecting from a sloping roof. The slope of the roof is shown by the line *a b* in view (*b*). It is required to find the elevation of the shadow cast by the chimney stack on to the sloping roof. Beginning with the point or corner of the stack, shown at *c'* in view (*a*) and at *c* in (*b*), draw a ray from *c* meeting the roof plane at *c''*. A horizontal projector from *c''* across to the elevation will cut a ray from *c'* at the point *C*, which will be the elevation of the shadow of point *c'* on the roof plane. In a similar manner, draw a ray through *d* to cut the roof plane at *d''*. A horizontal projector drawn from this point across to the elevation will cut at *D* a ray drawn from *c'*, which point coincides

with d in the elevation. The line $C\,D$ is the shadow of the edge $c\,d$ of the stack.

82. The shadow of the edge $E\,c'$ will commence at the point E in view (a) and at e'' in (b). A line $E\,C$ will therefore represent the shadow on the roof of the edge $E\,c'$. Other points in the shadow boundary can be found in the same manner by drawing rays from points f, g, h, i, j, k, l, and m, which rays will meet the roof at points f'', g'', i'', k'', and l''. If projectors are drawn from these points across to the elevation so as to meet rays drawn from the points f', g', h', i', j', k', l', and m', the points of inter-

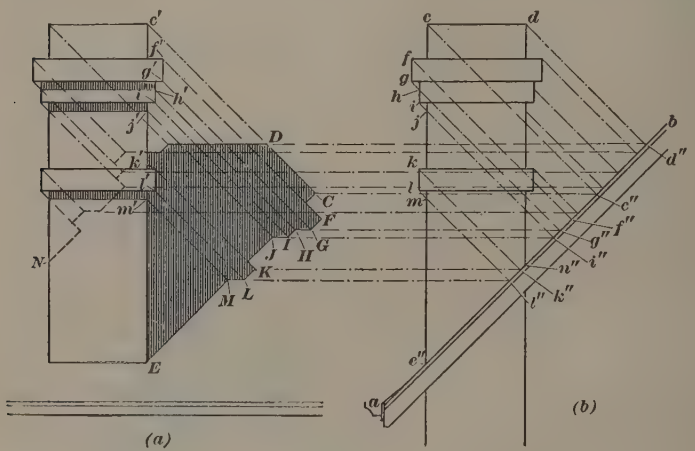


Fig. 37

section will give the points F, G, H, I, J, K, L, and M on the shadow outline. The left-hand side of the shadow falls behind the stack and is therefore shown by dotted lines. The point N, where this part of the shadow begins, is indicated in view (b) by the point n'', and is the point at which the rear face of the stack leaves the roof.

It is of advantage to work out a number of problems of the kind shown in Fig. 37, because they give opportunity for a practical application of the principles explained in this Section. There are a great number of problems that may be selected for

this purpose and which can be solved without difficulty by simply applying the methods previously outlined. By solving such detail problems, the insertion of shadows in large architectural drawings will be a simple process, because it will simply consist of a combination of elementary problems.

83. Frustum of a Pyramid and a Series of Steps.—Fig. 38 (*a*) and (*b*) shows the elevation and plan of the frustum of a pyra-

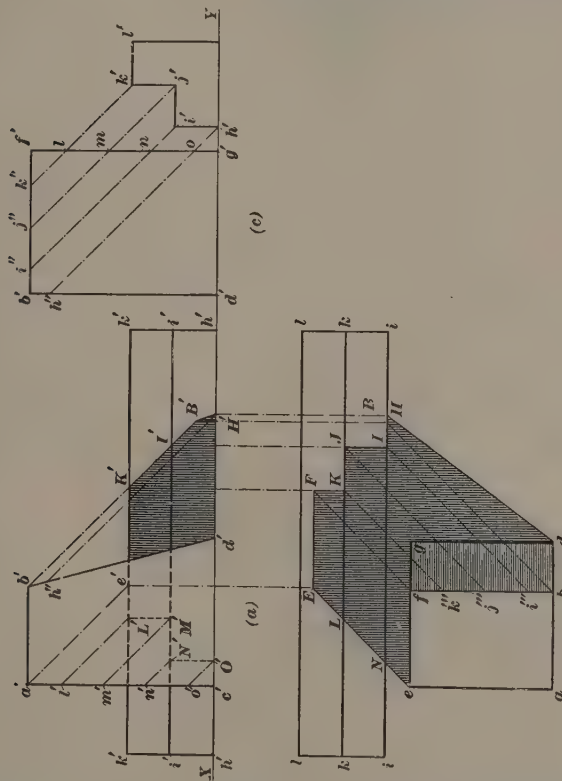


Fig. 83

mid $a'\,b'\,d'\,c'$ and two steps $i\,k\,l$. It is required to find the shadow of the frustum on the **HP** and on the steps. The part of the

problem that needs some explanation is the method by which to find the shadow of the edge $b\,f$ on the steps. It is evident that this shadow will be broken up into a series of lines, and the problem is to find the positions and inclinations of these lines. Some of the rays passing from the edge $b\,f$ will of necessity meet the corners h, $i\,j$, and k of the steps, and if the positions of these rays can be ascertained, the solution of the problem will offer no difficulties.

If a series of intersecting planes $h'\,h''$, $i'\,i''$, etc., are passed through the frustum at an angle of 45°, so as to meet the corners of the steps, as shown in view (*c*), it is clear that the required rays must be situated somewhere in these planes. To find their exact positions it is necessary to transfer, by measurement, the points of intersection i'', j'', and k'' from view (*c*) to view (*b*), as at i''', j''', and k'''. If, now, rays are drawn from these points, they are all situated in the intersecting planes, indicated in view (*c*), and they must therefore intersect the step corners. The points of intersection I, J, and K are therefore points in the shadow boundary. The point h'' in the plane $h'\,h''$, Fig. 38 (*c*), is projected over to view (*a*) ; a ray from this point intersecting line $h'\,h'$ gives point H'. The shadows of points b and f are found at B and F in the usual manner, remembering that they are situated in different planes. After connecting points d and H in **HP**, and the other points in both planes, the shadows of the edges $f\,b$ and $b\,d$ are complete.

84. There remains yet to be found the shadow of the vertical edge, of which e in view (*b*) is the top point. For this purpose the points of intersection l, m, n, and o in (*c*) are projected over to the edge $a'\,c'$ in view (*a*). Rays drawn from these points to corresponding corners give L', M', N', and O' in the shadow boundary. The shadow of point e is found as usual. After these points have been connected the shadow is complete. A clearer understanding of the positions of the various points from which the rays proceed may be had by examining Fig. 39. The latter is a perspective view of Fig. 38, and shows at once the position of the points in the shadow boundary, and the relation between them and corresponding points on the frustum. It shows also

the edge $e\,p$ that throws the shadow $E\,L\,M\,N\,O$. If the principles involved in the solution of this problem are well

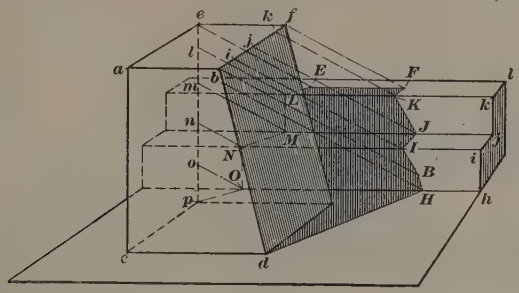


Fig. 39

understood, they will serve as a means for an easy solution of problems that otherwise would seem difficult.

SHADES AND SHADOWS ON CAPITALS

85. When columns are contained in an architectural drawing, it would require a great amount of time and labour if the shades and shadows on these were to be defined by projection. In most cases it is sufficient if the shading is only approximately correct. However, any glaring errors ought even then to be avoided, and it is therefore advisable that the positions of the main points are ascertained by projection. The remaining points can be inserted partly by eye and partly by some empirical method. Figs. 40 to 42 show the capitals of three columns used extensively in architectural design. The purpose of inserting these views is that they may serve as guides in shading similar columns when required. Fig. 40 represents the cap of a Tuscan column, Fig. 41 the cap and base of an Ionic column resting on a pedestal moulding, and Fig. 42 the cap and base of a Corinthian column.

86. Fig. 40 serves the further purpose of illustrating how the positions of some of the more important points may be found by empirical methods. But it must be distinctly understood

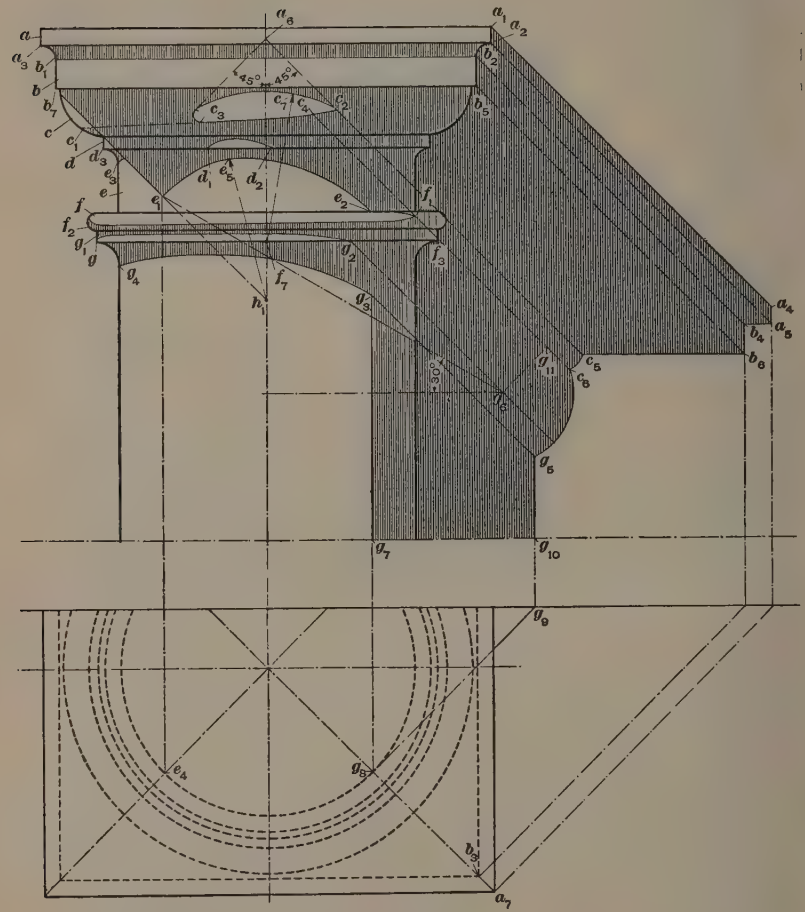

a
a3
b1
b
b7
c
c1
d
d3
e3
e
f
f2
g1
g
g4
a6
a1
a2
b2
45°
45°
c3
c7
c4
c2
b5
d1
e5
d2
e1
e2
f1
g2
f3
h1
f7
g2
30°
g11
c5
c8
a4
a5
b4
b6
g5
g7
g10
g9
e4
g8
b3
a7

Fig. 40

that the construction shown in Fig. 40 does not, with the exception of some important points, represent the method followed in the orthographic projection of the shadows. On the contrary, most of the points have been found by empirical means, and the results are therefore only approximately correct.

Beginning with the fillet a, at the top of the capital, its shadow on the abacus b is found by drawing a ray through the corner a_3 intersecting the abacus at b_1. A horizontal $b_1\, b_2$ through the latter point will define the lower side of the shadow. The lower

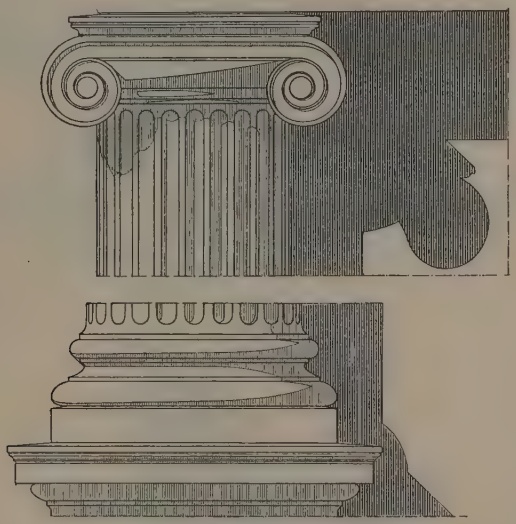


Fig. 41

left-hand edge of the abacus b, of which the point b_7 is the corner, projects at right angles to the vertical projection plane; the shadow of this line will therefore be defined by the ray $b_7\, e_1$, on which the point e_1 is fixed by projecting into the ray the point e_4 from the plan.

87. The ovolo c is nearly completely in the shadow of the abacus, the light areas being at the corner $b_7\, c_1$, and at the centre indicated by points c_3, c_7, c_2. The shade line of the ovolo is similar

to that shown in Fig. 30, the point c_1 being the point of tangency between a ray and the left-hand end. To find the points c_2, c_3, draw from point a_6 two lines $a_6\, c_3$ and $a_6\, c_2$ at an angle of 45° to the column axis and describe an arc $c_2\, c_3$ with a radius $c_7\, f_7$, the position of points a_6, f_7 being approximately as indicated. At c_2 and c_3 the arc is rounded so as to resemble one half of an ellipse.

The cincture d is nearly entirely in shadow; the lighted portions at d_1, d_2, and d_3 are easily defined. The point e_1 in the

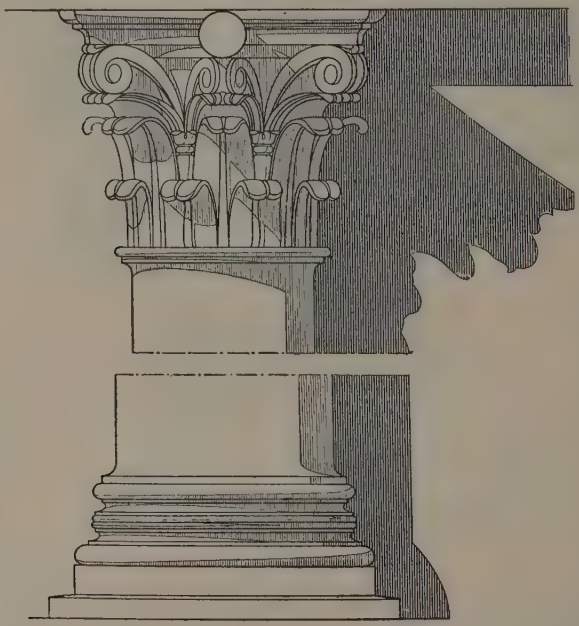


Fig. 42

shadow on the neck e has already been fixed. By using the line $e_1\, h_1$ as radius the curve $e_1\, e_5$ may be drawn; the other curve $e_5\, e_2$ has another centre and may be drawn by eye, taking care that the point e_2 lies on the line $g_3\, g_7$, produced. The shade line on the astragal f is similar to that of the ovolo c, the point f_1 being on the side of the column, produced. The shade line $g_1\, g_2$

on the lower cincture g is also of the usual form, likewise the shadow $g_3\, g_4$ of this cincture on the column, the point g_3 being on the line $g_3\, g_7$ found by projecting point g_8 from the plan to g_7 in the elevation.

88. There remains yet to be found the shadow of the capital on the wall, it being understood that the capital projects for a distance of two-thirds its diameter beyond the surface of the wall. The shadows of the points a_1, a_2, b_2, b_5 are found at a_4, a_5, b_4, b_6 by drawing rays from corresponding points in the elevation and from points a_7, b_3 in the plan. The curve $c_5\, c_6$ is found by drawing a ray through c_2 and another ray from c_4, passing through f_1. To draw the curve $c_6\, g_5$, proceed as follows : From the point g_2 draw a ray $g_2\, g_6$, and from the point e_1 a line inclined at 30° to the horizon and intersecting $g_2\, g_6$ at g_6. With a radius equal to the distance $g_6\, c_6$ and with g_6 as a centre, draw the arc $c_6\, g_5$. The position of the line $g_5\, g_{10}$ is found by means of the rays $g_3\, g_5$ and $g_8\, g_9$ in the manner shown. It is evident that this empirical method will apply only to a capital of the proportions indicated. For one of other proportions, a similar method may be employed after the correct outlines of the shades and shadows have been ascertained from some standard drawing.

SKETCHING AND MEASURING

MATERIALS AND INSTRUMENTS

INTRODUCTION

1. Perhaps one of the most interesting subjects to the majority of architects, and one that is highly important to an architect who wishes to be fully qualified to design buildings that will be of pleasing composition and detail, is **sketching and measuring.** Nothing impresses a design or detail on the memory, or helps the memory to retain an impression, so much as a carefully made sketch or measured drawing. Almost unconsciously the mind becomes saturated with types of good design and detail, and a knowledge and sense of good proportion is cultivated that is sure to express itself when problems of design have to be solved. Knowledge gained in this way is knowledge at first hand ; it cannot be obtained by reading, for it shows the difficulties met by men who built, perhaps, ages ago and the methods they adopted to overcome them. It is not necessary for a sketch to be a picture ; a book full of pretty sketches is not so useful nor so workmanlike as one filled with sketches showing how difficult problems of design and construction have been solved. Pictures and pretty sketches are all right in their place, but sketches supplemented by ample measurements and notes indicating the materials and any peculiarities in design not previously encountered are far more valuable when some problem of design or construction presents itself for solution. A young architect, with his collection of sketches of widely differing subjects, is much better equipped for his work than one who

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obtains his inspiration from books only. Invariably, the capable architect is one who has devoted much time to the study of buildings and their detail accompanied by his sketch book.

2. Style.—Style in sketching is as varied and distinct as in handwriting, and must be developed along natural lines by untiring perseverance and close study of ornamental and constructional detail. The real value of a sketch is just in proportion to the amount of knowledge gained by its execution. All the rough pencil jottings in a sketch book should be of value and made for a definite reason, they being a direct training for hand and eye, and the more valuable as knowledge of detail increases.

3. Standards of Proportion. — Many of the standards of proportion and design in use at the present day are derived from the Classic Orders as exemplified in the Grecian and Roman temples and public buildings. The remains of these buildings have been the subjects of innumerable sketches and measured drawings, records of which are preserved in books and drawing plates to be referred to by those unable to study from the original buildings. Every architect should study the buildings and monuments accessible to him. By constantly sketching, both complete buildings and details of them, he will find that a high sense of good proportion will be almost unconsciously cultivated.

MATERIALS USED

4. Pencils.—The quickest, and in many ways the most satisfactory, medium for outdoor sketching is the pencil, but cheap pencils must never be used, for they will not give good results. Among those which can be safely recommended are Hardtmuth's Koh-i-noor pencils and Wolff & Sons' selected leads. The most suitable grade will depend on the individual taste, but probably a B grade is most suitable for rapid sketching and for general work, a HB for outline sketching and measured work, and a BB for emphasizing dark masses and shadows. There is no more responsive medium than a pencil, for all tones from the lightest grey to the densest black can be obtained with it, yet no medium calls for more subtle handling.

5. Paper.—The **paper** should be of good make, for here also it is false economy to buy cheap material. Its surface should be inclined to smoothness with just sufficient texture to enable the pencil to *bite*. For convenience in handling for outdoor sketching, the paper is usually made up into **sketch books,** or **blocks.** The book protects the sketches, and gives less chance for any one of them to be lost, but the block, which consists of a number of sheets of paper glued down by their edges to a stiff back of cardboard or millboard, offers a more solid surface to work upon, and for this reason alone is to be preferred when a careful drawing must be made. The block should be carried in a case having a flap pocket in which the sketches may be placed. When desired, a sheet of paper is easily removed from the block by inserting a knife blade between the two top sheets and passing it round the block to destroy the key of the glue. **Bristol-board** is often used instead of paper, and with great success, but it is of little use for rapid sketching. It has a hard, smooth surface, and is more suitable for pen-and-ink work than for pencil work ; however, with a soft pencil, clean sharp lines can be obtained on Bristol-board, which specially recommends it where a careful sketch of fine detail is to be executed, or when a drawing for reproduction has to be executed.

6. India-Rubber.—The **india-rubber** must be of good quality and of soft description. It should not be carried in the pocket or held in the hand for any length of time, as its very nature is such that it easily picks up any dirt. If these suggestions are not observed, it is more than likely that the first attempt to erase a line will cause a smudge on the drawing which will be very difficult to remove.

INSTRUMENTS USED

7. Besides the compasses, **T** square, set-square, etc., used in the drawing of geometrical forms, perhaps the most-used instrument is the *2-foot rule*, which should be used in connection with nearly every sketch made. A *5-foot rod* is used for taking larger dimensions ; it is generally made in two lengths connected with a spring joint, which permits the rod to be folded to about

one-half its length. A *plumb-line* and a small *tape* will be found indispensable when measuring old or new work. When measuring work of any importance, a *spirit level*, *calipers*, and *long tape* will be necessary. The best type of spirit level for this purpose contains two levels, one for horizontal and one for vertical use, is 12 inches long, and has a scale graduated in fractions of an inch on both sides. Calipers somewhat resemble a pair of compasses and are used for taking measurements in positions inaccessible to the rule, and for which the tape is unsuitable. The long measuring tape may be of linen or of ribbon steel. The latter is less susceptible to alteration in length, but requires great care in use, as it must not be bent sharply, trodden upon, nor exposed to a damp atmosphere unless oiled, for it will rust easily. It should be noted, in taking dimensions with the tape, that all measurements commence from the extreme outer edge of the ring at its free end, for the length of the ring is included in the first inch marked on the tape.

The method generally adopted by one holding the free or ring end of the tape, when measuring, is to place the thumb in the ring and press it tightly against the face from which a measurement is desired. This ensures that the end of the tape will be in its correct position, and also allows the tape to be pulled tight by the person reading the dimension at the other end.

FIXING A DRAWING

8. In order to minimize the risk of smearing or smudging it, the finished sketch should be **fixed.** This is done by soaking the sheet on which it has been made in water, which makes the paper porous, so that it will to a certain extent absorb the lead on its surface. This method is both simple and effective, and is absolutely necessary when a soft pencil has been used for the drawing. Many patent fixatifs have been introduced. These are composed chiefly of a preparation of liquid gum arabic and can be sprayed on the drawing and so fix the pencil lines ; but nearly all these preparations stain the paper and therefore are not to be recommended. Milk washed over a pencil drawing will fix it, but may leave a stain.

ROUGH SKETCHES AND NOTES

EXAMPLES

9. When speaking of a **rough sketch** or **note**, it is not meant that the sketch is to be carelessly done, but rather a quick sketch

FIG. 1

or note is drawn of some subject or feature in distinction from a more ambitious pictorial representation of the same thing.

Such sketches, accompanied by some of the leading dimensions and notes as to material, construction, colour, etc., form invaluable reference matter when circumstances call for the creation of ideas which must be realized in some tangible form. They do not comprise the completeness of a measured drawing, but in their way are just as useful. The following examples can be taken as types of the sketches to be made and show a method of making the drawings, but they should not be taken as types of style, for this rests entirely with the individual. An effort should be made to jot down notes of features, however simple, that appeal to an architect in his walks about towns and villages to which business or pleasure may take him.

10. The drawing of the Gothic porch shown in Fig. 1 gives a good idea of a type of sketch that is well adapted for use as a rough sketch or note. It is drawn simply and with but little indication of shadow, but the addition of the small sketches of mouldings and details, together with a few leading dimensions, give it a value beyond a mere pictorial sketch. It has purposely been rendered almost entirely in outline, for this type of sketch should be regarded as the shorthand note, the value of which depends on the amount of lasting information it gives to the artist who made it.

11. The shorthand nature of the sketch is probably better illustrated in Fig. 2, the subject of which is a group of small picturesque country houses. A portion of the sketch is treated in a pictorial manner, but the remainder is entirely diagrammatic, for its purpose is to serve as a key for locating the various sketches of details which are indicated. Apart from this, however, this portion of the sketch possesses some interest, for it shows the effect of the grouping of the various features forming the design. When the preliminary perspective sketch of the cottages has been made, the prominent features of the subject are selected for separate studies, such as the gables, chimneys, mouldings, etc. Notes should be made unsparingly of any peculiarities or points that may be useful for future reference. Subjects of this type may not be of sufficient architectural importance to merit the making of carefully measured

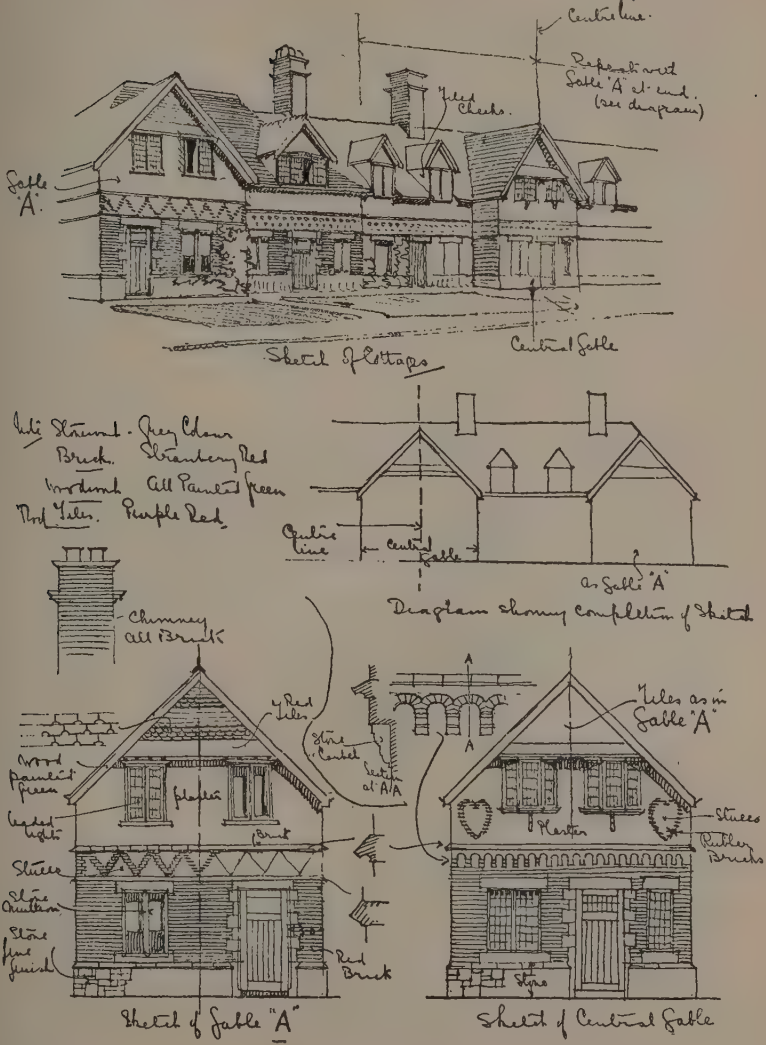
Centre line.
Repeat with Gable "A" at end. (see diagram)
Tiled Cheeks.
Gable "A".
Central Gable
Sketch of Cottages
Note Stonework - Grey Colour
Brick. Strawberry Red
Woodwork All Painted Green
Roof Tiles. Purple Red
Centre line
Central Gable
As Gable "A"
Diagram showing completion of Sketch
Chimney all Brick
Red Tiles
Wood Painted Green
plaster
Leaded lights
Brick
Stone Corbel
Section at A/A
Stucco
Stone Mullion
Stone fine finish
Red Brick
Sketch of Gable "A"
A
A
Tiles as in Gable "A"
Plaster
Stucco
Rubber Bricks
Stone
Sketch of Central Gable

FIG. 2

drawings, but the addition of measurements of the more important parts will give a scale to the whole, and enable the proportions of the original to be reproduced correctly if at any time it is desired to do so.

A method of obtaining the approximate heights of the various portions of the building is by counting the brick courses ; as a general rule, for ordinary brickwork four courses may be taken as measuring 1 foot. To obtain a scale by which to work for the particular building in question, two or three sets of four courses each should be measured at the ground level with a 2-foot rule ; an average can be taken between these dimensions,

FIG. 3

and then when the total number of courses up to any point has been counted, the dimension can be easily worked out with surprising accuracy. The pleasing effect of the brickwork may possibly be produced by the size of the brick used. This should be noted carefully, also the method of pointing, colour of mortar joints, etc. These facts are mentioned because they may pass the observation of the beginner as being unworthy of special attention. It will be observed that a note on the

sketch says that the gables *A* at the ends of the building are similar in design, with one exception; the gable on the left-hand side has the doorway to the left of the window, while the detail sketch of gable *A*, given in the lower left-hand corner of Fig. 2, shows that the gable to the right-hand side of the building has its doorway to the right of the window. Such points as this should be carefully noted, so that, on referring to the sketch at any future time, no doubt may arise in the mind as to the exact finish of any particular portion of the original design from which the sketch was made.

12. A sketch of somewhat similar character is shown in Fig. 3, where the pleasing grouping obtained by the intersections of the roofs should be noted. It will be noticed that simply from the notes it is known that the building has a stone plinth, red-brick lower story, plastered walls to the first floor, a red-tile roof, brick string-courses, and a tiled gable. It would be hard to give a more complete and true idea of the original composition without the use of colour, but a sketch in colour would take very much longer to complete.

13. A sheet of sketches, less comprehensive and more detailed than those previously given, is shown in Fig. 4. It shows the method of finish to jamb and sill on a Gothic window because this finish is somewhat out of the ordinary, the jamb mouldings in ordinary cases running down to the sill. The stone truss and shield are interesting and useful as details of carving which may be easily adapted to the design in other buildings. The sketch of the corner of a house with stone quoins and moulded cornice, together with the details of the various parts, gives a good idea of finishings that may often be used in similar situations. A rough sketch of a gable finial may be helpful with many others that have been or will be obtained, when problems in such items of design present themselves. The importance of such rough-and-ready notes is perhaps not fully realized until suggestions are required in the designing and detailing of a building. It may not be necessary to reproduce such features in facsimile, but they will suggest some fresh idea and can be remodelled into harmony with the work being designed.

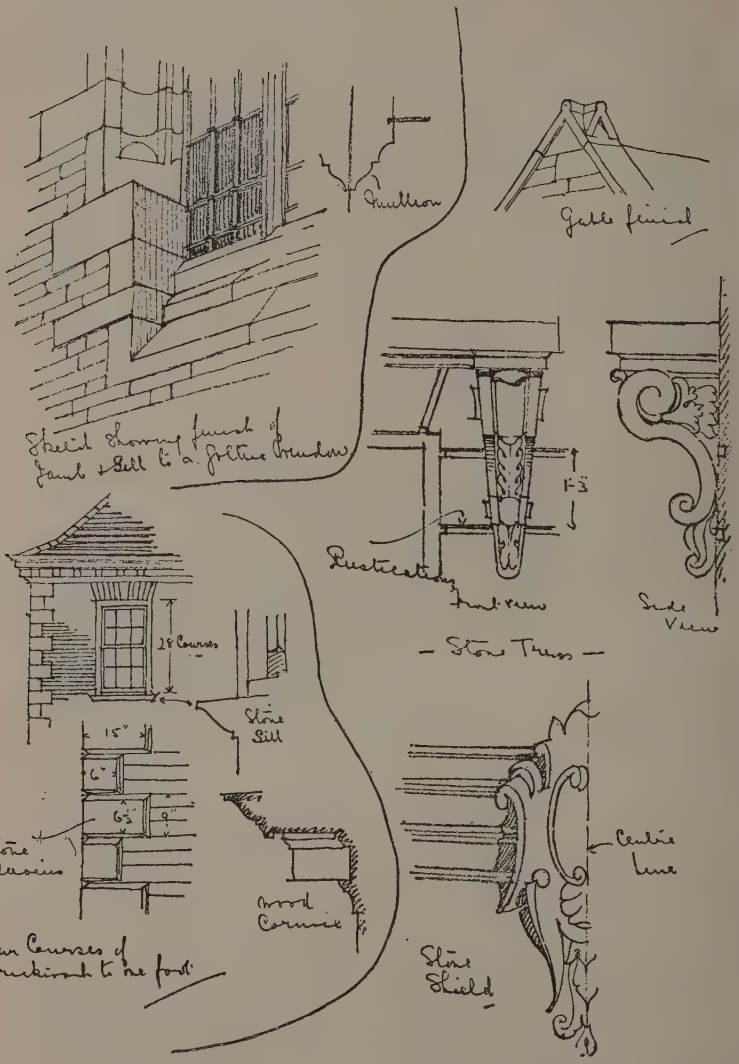
Mullion
Gable finish
Sketch showing finish of Jamb & Sill to a Gothic Window
1'-3"
Rustications
Front view
Side View
— Stone Truss —
28 Courses
Stone Sill
15"
6"
6½"
9"
Stone Quoins
Wood Cornice
Four Courses of brickwork to one foot
Centre line
Stone Shield

FIG. 4

MEASURED WORK

PRELIMINARY INSTRUCTIONS

14. Definition. — A **measured drawing** is one that shows exactly, to scale, in plan, elevation, or section, the building or object to be represented. It takes no account of perspective, but simply shows the details and parts geometrically, with the result that a drawing similar to the one probably prepared by the architect for the builder to work from when erecting the structure is produced. Sufficient measurements must be taken from the building or object to enable the complete details to be drawn ; these are then drawn, or *plotted*, to scale. The drawing of measured work is now recognized as the best form of instruction in the principles of detail and design, for drawings made from one's own sketches and measurements are more valuable, from an educational point of view, than those of the same subject made by others.

15. Plotting.—The process of reproducing the subject on drawing-paper from the measurements taken is termed **plotting.** This is done to scale, the scale selected depending on the size of the drawing required. The object in view should be to make the finished drawing so complete that if it were handed to a builder, a replica of the subject measured could be made. The plotting is often done in the office, or at home, frequently some time after the measurements are taken, but in the case of a large or intricate subject the work should be plotted on the site at the same time that it is measured, so that the drawing will not be delayed by the lack of a dimension. Should a certain measurement be required, it can be obtained at once when plotting is done on the site, but some time may elapse before the information can be obtained when plotting is done at home. As a rule, it will not be difficult to take a drawing-board,

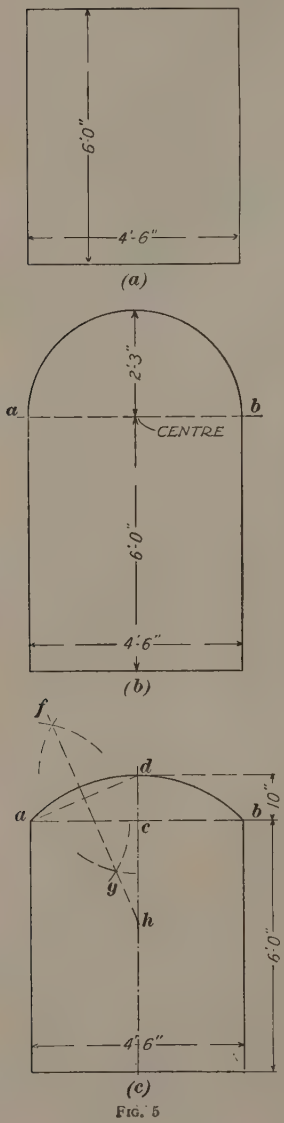

FIG. 5

T square, and drawing instruments to the site, as they can generally be left in the care of some one on the building; and a subject that is of sufficient importance to plot on the site will in all probability take several days, or even weeks, to measure.

MEASURING SIMPLE OPENINGS

16. Before work can be satisfactorily measured, the underlying principles and methods must be thoroughly understood. In Fig. 5 (*a*), (*b*), and (*c*) are shown three simple window openings which are to be measured. The one shown in (*a*) will present little difficulty, even to a beginner, as only two dimensions need be taken to obtain a drawing of the elevation. The width, 4 feet 6 inches, and the height, 6 feet, should be measured carefully on the building and the dimensions plotted to scale on the drawing. The circular-headed window shown in (*b*) is a little more difficult to measure. The width, 4 feet 6 inches, and the height, 6 feet, to the springing line *a b*, are taken and plotted as before. The difficulty is to measure the curve, the height of which must first be obtained. Lay a long straightedge across the springing line and measure from this line to the crown of the arch; this distance is found to be 2 feet

3 inches. As this is exactly one-half of the total width of the window and the curve is regular, it is a semicircle and may be turned in with the pencil bows from the point where the centre line of the window opening cuts the springing line *a b*.

In Fig. 5 (*c*) a more difficult problem is shown, for the window has a segmental head. The width, 4 feet 6 inches, and the height, 6 feet, to the springing line *a b*, are measured as before, and then the rise *c d* of the arch, which in this case is 10 inches. When plotting this opening, the same process is gone through as described for view (*a*), but *a b* is dotted in as the springing line. The centre line *c d* of the opening is then drawn in, and from the point *c* which is at the intersection of the springing line the distance *c d* is set up equal to the rise of the arch. Join *a* and *d*, and, from *a* and *d* as centres, describe arcs of equal radius intersecting at *f* and *g*. Through *f*, *g* draw the line *f g h* which intersects the centre line of the window opening at *h*. Then the point *h* will be the centre from which the curve of the arch *a d b* is to be drawn.

MEASURING DOOR AND WINDOW PLANS

17. Taking the Dimensions.—In Fig. 6 (*a*) is shown a plan through a door opening showing how the dimensions should be taken to enable a correct plotting or drawing to be made. In (*b*) is shown the method of plotting the dimensions taken. In taking the dimensions from the building, great care should be taken to obtain what are called **over-all dimensions**; that is, the dimensions should be taken right across the opening, when it is similar on both sides of a centre line, as in (*a*). First make a rough sketch of the plan on which the dimensions can be placed. Then the over-all dimension giving the width of the opening on the outside from *a* to *a'*, in this case 8 feet 5 inches, should be measured and put down on the rough sketch, with arrowheads clearly defining at what points the dimension was taken. The next dimensions to be taken and noted will be *b b'* equal to 6 feet, *c c'* equal to 6 feet 6 inches, *d d'* equal to 7 feet 1 inch, and *e e'* equal to 8 feet 3 inches. From *a* measure *a f* equal to 3 inches, and from *a* measure *a g* equal to 1 foot 6 inches. To obtain this dimension, lay a straightedge along the face *h a* of the front wall

projecting out toward the centre of the door opening and from this measure back carefully to the point *g*. From *g* measure to *i* 8 inches, from *j* to *k* 8 inches, and from *l* to *m* 6 inches. Then measure from *m* to a straightedge laid along the face of the wall *n e* 12 inches. In a similar manner the dimensions on the other side of the doorway may be taken, but they will probably be found to be similar. The dimensions having all been obtained and carefully noted on the sketch made, it only remains to plot them to scale.

18. Plotting the Dimensions.—In Fig. 6 (*b*) is shown the method to be used in plotting the dimensions taken in Fig. 6 (*a*). Wherever possible, that is, where an opening is similar on both sides of a centre line, the dimensions should be plotted from a centre line. The first thing to do, therefore, is to draw a faint line through *h h'* in (*b*), on which should be plotted, to whatever scale it has been decided to work, the dimension *a a'* in (*a*) equal to 8 feet 5 inches. Bisect *a a'* in (*b*) at the point *o* ; from *o* set up the line *o p* at right angles to *a a'*, this will be the centre line of the doorway opening. Now, from *a* in (*b*) set up *a f* equal to *a f* in (*a*), or 3 inches. On each side of the centre line *o p* set off 3 feet and draw through the points so found lines parallel to *o p* ; these lines will give the faces equivalent to *b b'* in (*a*). From *a*, *a'* in (*b*) set up a dimension of 1 foot 6 inches at right angles to *h h'*, and draw through the point so found a line parallel to *h h'*, which will cut the lines on which the faces *b b'* are situated at *g* and *g'*. Join *g* and *f* and *g'* and *f'*, and the splays so found will be equivalent to the splays *g f* and *g' f'* in (*a*). From *g* and *g'* set off the dimension *g i* and *g' i'* equal to 8 inches at right angles to *h h'*, and through *i* and *i'*, draw the lines *i j* and *i' j'* indefinitely, but parallel with *h h'*.

On each side of the line *o p* set off the dimension 3 feet 3 inches, which is equal to one-half the dimension *c c'* in (*a*). Through the points so found draw the lines *j k* and *j' k'* indefinitely, but parallel with *o p*, cutting the lines *i j* and *i' j'* at *j* and *j'*, thus giving definitely the points *j* and *j'*. From *j* and *j'* measure along the lines *j k* and *j' k'* the distance 8 inches as shown at *j k* in (*a*), and through *k* and *k'* draw the lines *k l* and *k' l'* parallel

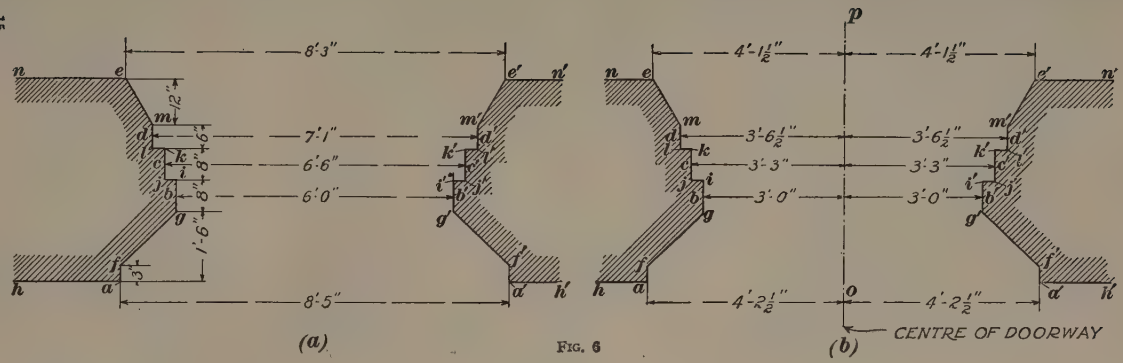
8'-3"
7'-1"
6'-6"
6'-0"
8'-5"
1'-6"
12"
6"
8"
8"
3"
(a)
4'-1½"
4'-1½"
3'-6½"
3'-6½"
3'-3"
3'-3"
3'-0"
3'-0"
4'-2½"
4'-2½"
CENTRE OF DOORWAY
(b)

FIG. 6

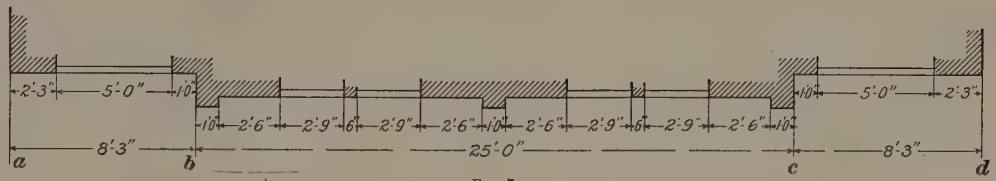
2'-3"
5'-0"
10"
10"
2'-6"
2'-9"
6"
2'-9"
2'-6"
10"
2'-6"
2'-9"
6"
2'-9"
2'-6"
10"
10"
5'-0"
2'-3"
8'-3"
25'-0"
8'-3"

FIG. 7

with $a\,a'$. Measure off the distance 3 feet $6\frac{1}{2}$ inches on each side of $o\,p$, and through the points so found draw lines indefinitely parallel with $o\,p$, cutting $k\,l$ at l and $k'\,l'$ at l' and fixing definitely the points l and l'. From these points, draw $l\,m$ and $l'\,m'$ equal to $l\,m$ in (a), or 6 inches, and from m and m' set off a dimension of 12 inches at right angles to $h\,h'$, as shown in (a). Through the point so found draw a line $n\,n'$ parallel with $h\,h'$. On each side of $o\,p$ set off the dimension 4 feet $1\frac{1}{2}$ inches, and through the points so found draw lines parallel with $o\,p$, cutting the line $n\,n'$ at e and e'; join e and m and e' and m', and the plotting will be complete. The setting-up lines can then be carefully rubbed out, and the lines indicating the plan of the doorway can be inked or lined in.

CHECK DIMENSIONS

19. In important work, all detail measurements should be checked by taking the over-all dimensions in all places possible. If these dimensions and the sum of the detail measurements agree, the detail measurements may be taken to be correct. Fig. 7 shows the plan of a front wall of a house in which a series of running dimensions have been taken to indicate the positions of the various window openings, projections, recesses, etc. As the smaller dimensions have been obtained with the 5-foot rod or the 2-foot rule, though every care has been taken to get the dimensions accurate, each may be $\frac{1}{8}$ or $\frac{1}{4}$ inch wrong. To check up these smaller dimensions, therefore, over-all or check dimensions have been taken at $a\,b$, $b\,c$, and $c\,d$, which it is found agree with the smaller dimensions when added up, thus proving that the shorter dimensions are correct.

MEASURING PLANS OF BUILDINGS

20. System of Triangulation. — In measuring and plotting the plans of buildings, problems and difficulties will constantly arise which can, however, in all cases be settled by the application of the principle of **triangulation.** It is known from geometry that if the lengths of two sides of a triangle are known the exact

angle which they contain can be determined by measuring the third side and plotting the triangle on paper. This system of triangulation is applied to the measuring of rooms or plans; for, if the length of the two sides of a room is known, the angle at which the two sides meet can be accurately determined by measuring the diagonal across the room or across from two points in two adjacent sides of a room, thus dividing it into a series of triangles. On entering a room of rectangular form, the plan of which is to be measured, it would appear to the beginner that only four dimensions, that is, the length of each wall, were necessary to make its plan complete, but to obtain an accurate plan, at least five dimensions must be taken. Fig. 8 (*a*) shows the plan of a room *a b c d* in which the lengths of the walls are, respectively, *a b*, 25 feet; *b c*, 20 feet; *c d*, 25 feet;

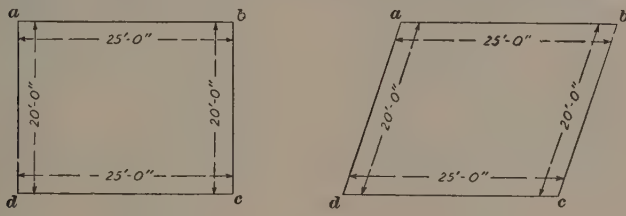

FIG. 8

and *d a*, 20 feet. In (*b*) is shown the plan of a room *a b c d*, having walls *a b*, *b c*, *c d*, and *d a* of exactly the same dimensions, but the plans of the two rooms are very unlike. Therefore, if only the dimensions representing the lengths of the four walls were taken, very different results might be obtained in the plotting.

21. To obtain the correct plan of a room, unless it is known to be quite rectangular, at least five dimensions are necessary. In Fig. 9 (*a*) is shown the method that should be adopted to obtain an accurate plan of the room shown in Fig. 8 (*a*). Diagonal dimensions *a c* and *d b* which divide the room into a series of triangles should be taken. The diagonals *a c* and *d b* are each 32 feet, which dimension is as correct as it would be possible to obtain it with the average tape, though if the triangle *a d c*

is a right-angled triangle, with the sides *a d* and *d c* forming the right angle, the side *a c*, or the hypotenuse, will actually be slightly more than 32 feet.

In Fig. 9 (*b*) is shown the correct method to be adopted in measuring the room shown in Fig. 8 (*b*). Here diagonal dimensions *a c* and *b d* are taken and give the correct angle at any point *a*, *b*, *c*, or *d* of the room. To plot a room of this shape when the diagonals have been taken, draw the line *a b* correctly to scale and equal to 25 feet. Then, with *b* as a centre and a radius of 20 feet, describe an arc of a circle in about the position where it is thought *c* will occur. With *a* as a centre and a radius of 26 feet $4\frac{1}{2}$ inches, describe another arc cutting the previous one in the point *c*. Join *b* and *c*, and the angle *a b c*

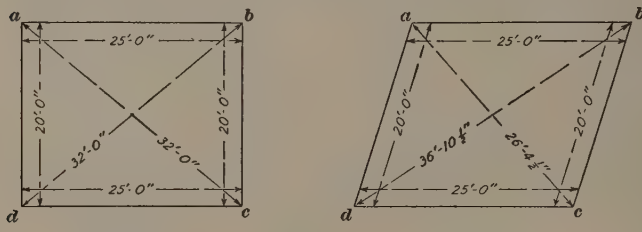

FIG. 9

will be the correct angle at which the sides *a b* and *b c* join one another. With *a* as a centre, describe an arc of 20 feet radius to scale at about the position where the point *d* may be expected to come, and from *b* as a centre with a radius of 36 feet $10\frac{1}{2}$ inches describe an arc cutting the previous one at the point *d*. Join *a* and *d* and *d* and *c*, and if the working of the plotting has been done accurately, the dimension *d c* will scale exactly 25 feet. If this does not scale correctly, the whole of the working out must be done again. Great care must be taken in plotting such dimensions as this, as incorrectness to the extent of the thickness of a line will often put out the whole of the plotting.

22. In Fig. 10 is shown the plan of a room that is more difficult to measure than the examples previously given, for one of the side walls *a f e d* is not in a straight line. As before,

none of the angles of the room should be assumed to be right angles, but all should be *tied in* by a series of diagonal dimensions. This room should be measured as follows: First measure the length of all the walls, as *a b*, *b c*, *c d*, *d e*, *e f*, and *f a*. Then carefully take all the diagonal dimensions, as *a c*, *b f*, *b d*, and *c e*, by which means it will be found that the area of the room has been divided into a series of triangles, each of which can be plotted as described in Art. **21.**

To plot the room shown in Fig. 10, first measure off on the paper a line *a b* equal to 20 feet; then, with *b* as a centre and a radius of 25 feet, draw an arc about the position where *c* is expected to be. With *a* as a centre and a radius equal to the diagonal *a c*, cut the previous arc at *c*. Join *b* and *c*, and two

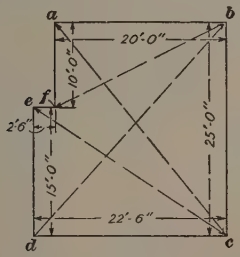

Fig. 10

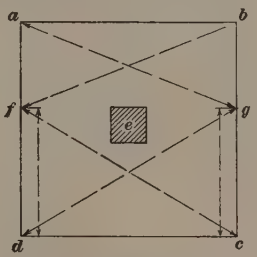

Fig. 11

sides of the room will be drawn in correct relation to one another. With *a* as a centre and a radius of 10 feet draw an arc about the position where *f* is likely to occur, and with *b* as a centre and a radius equal to the diagonal *b f* cut this arc at the point *f*. Join *a* and *f*. In a similar manner the point *d* is found by intersecting arcs drawn with *b* and *c* as centres, and *e* is found by intersecting arcs drawn with *c* and *d* as centres. The only remaining work to be done after joining up these points is to join *e* and *f*, which, if the plotting has been correctly done, should measure exactly 2 feet 6 inches, as shown.

23. Obstructions.—It often occurs, when measuring rooms, that it is not possible to take diagonal dimensions across a room owing to the existence of some obstruction, such as a column or piece of furniture. When this occurs some such scheme must

be resorted to as is shown in Fig. 11. Here the diagonals *a c* and *b d*, Fig. 10, cannot be taken owing to the obstruction *e*, so artificial points must be adopted as a basis for the system of triangulation. On the walls *a d* and *b c*, any two points *f* and *g* distant as far as possible from the corners *d* and *c* should be taken. Dimensions should be taken from *d* to *c*, from *d* to *f*, and *f* to *c*, which will give sufficient information for the triangle *f d c* to be plotted. Next take the dimensions *g c* and *g d*, which will permit the triangle *g d c* to be plotted, as the line *d c* is common to both triangles. Measure the walls *d a* and *c b*, and plot them on the drawing, producing the lines *d f* to *a* and *c g* to *b*. Join *a* and *b*, which should scale on the drawing exactly what it measures on the building, but, as an additional check, the diagonal dimensions *f b* and *g a* should also be taken, thus ensuring accurate work. Cases might be multiplied indefinitely in which this principle of triangulation would save both time and labour; and it will be found that the whole system of measuring up buildings, of which kind of work the architect has to do more than any other, is based upon it, so that it is essential that a thorough mastery of its principles should be obtained.

MEASURING PROJECTING FEATURES

24. Square Bay.—In Fig. 12 is shown the plan of a square bay window, the measurements of which have to be taken from

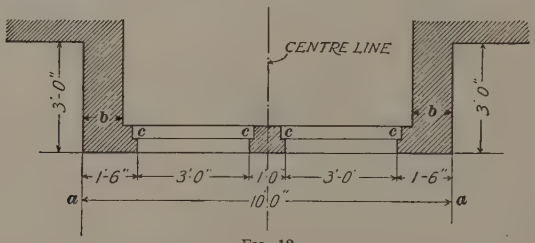

Fig. 12

actual work. First make a pencil sketch as nearly in correct proportion as possible, on which the measurements may be placed as they are taken. The dimensions to be taken are quite

simple and straightforward, and all that are necessary are shown on the figure. The overall, or check, dimension is shown at *a a*. If it is desired to draw accurately the thickness of the wall *b* and the detail through the window jambs *c*, the procedure will be similar to that described in Arts. **17** and **18.**

25. Bay With Splay Sides.—In Fig. 13 is shown a variation of the square bay in that two of its corners are cut off and are formed into splay sides, as at *b c* and *d e*. To measure such a bay as this, first make the pencil sketch and put on it the dimensions *a b*, *b c*, *c d*, *d e*, and *e f*, which will give the sides of the bay all round, but will not give the angle of the splay. This may be obtained by producing the line *d c* to *g* by means of a board or straightedge ; also produce the line *a b* to *g*, care being taken that *a g* is at right angles to *d g*, which can be checked by

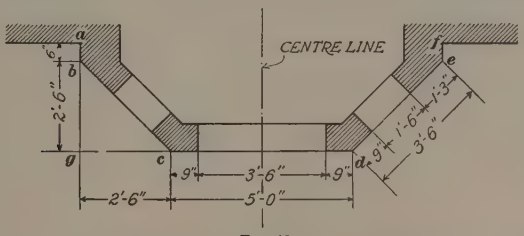

FIG. 13

means of a set-square. Now measure *b g* and *c g* and carefully place these on the pencil sketch, when it will be found that the angle of the splay can be plotted quite easily. The other side of the bay should be treated in a similar manner, as a check to find out whether or not both sides are similar. The window openings in the walls and the thickness of the wall will be obtained in a manner similar to that before described. The dimensions on both sides of the centre line will probably be found to be similar, so that the length of *b c* can be taken to be the same as the length of *d e*, or 3 feet 6 inches, as no note is made to the contrary. For a similar reason, the splay *d e* can be taken at a similar angle to *b c*, and the dimension *e f* to *b a*.

26. Segmental Bay.—In Fig. 14 is shown a more difficult problem to measure than those in Figs. 12 and 13. As before,

the first thing to do is to draw the pencil sketch, after which a base line *d e* must be laid down on the ground, if possible, either in chalk or by means of a long lath or piece of timber. This base line *d e* must be tangential to the curve of the bay at *a* and parallel with the main wall line *g f*. To ensure its being parallel to the wall line, set it approximately so and measure *e f* and *d g*, then move the rod or line backwards and forwards until the two dimensions *e f* and *d g* are equal, in this case 3 feet. Now, from *b* set up a line *b j* at right angles to *g f* and cutting the line *d e* at *h*, and from *c* set up a line *c k* at right angles to *g f*,

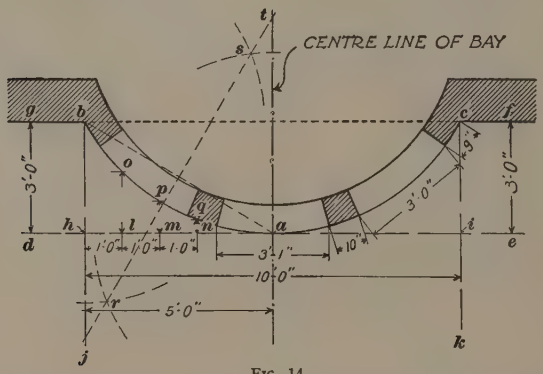

FIG. 14

cutting the line *d e* at *i*. Then measure *h i* along the line *d e*, when it will be found to be 10 feet, or the correct width of the bay at *b c*.

The correct width of the bay at the wall face, and the greatest projection of the bay to the face *a* from the wall line *g f*, are now known, but the shape of the curve is not yet determined. This is done by means of *offsets*, or a series of dimensions taken at right angles to the line *d e*, and at frequent intervals along it, to the curved face of the bay. From *h* measure off spaces along the line *d e* at any convenient distance apart, in this case 1 foot, as shown. At each of the points so found, *l*, *m*, *n*, set up lines at right angles to *d e* until they touch the face of the bay at *o*, *p*, and *q*. Then measure carefully *l o*, *m p*,

and *n q*; when plotting these dimensions a line drawn through the points *b*, *o*, *p*, *q*, *a* will give the correct curve for one-half of the bay. The other side may be measured in a similar manner. If the curve is regular, it may be drawn in with the pencil bows, in which case the correct centre for turning in may be found by joining *b* and *a*. Then, with *a* and *b* as centres, describe arcs of similar radius intersecting at *r* and *s*, join *r* and *s*, and produce the line until it cuts the centre line of the bay at *t*. The point *t* will be the centre of the curve of the bay *b o p q a*.

MEASURING MOULDINGS

27. Probably the most difficult architectural members to measure accurately are mouldings. In many cases the details of the mouldings are so small that the accuracy of the hand and eye must be depended on, and corrected as far as possible by measurements. Small mouldings should be drawn full size and the dimensions of each member taken off by the dividers and transferred to the drawing. Stone mouldings present fewer difficulties than wooden ones, for the members are generally larger and bolder.

28. Use of Lead Strip.—A method often adopted for obtaining profiles of mouldings is by means of a **lead strip** about $\frac{1}{2}$ inch wide and from $\frac{1}{8}$ to $\frac{3}{16}$ inch thick. This is carefully pressed over the moulding until the lead takes the correct profile, when it is removed and applied to the sketch book. The outline is traced on the paper with a pencil worked against the lead strip. Only short lengths of lead can be used, for the lead is so pliable that in a long length the template will lose its shape when being applied to the paper. This practice is only applicable to mouldings which have no undercutting, as in classic work, and is quite impracticable for the general run of Gothic mouldings.

29. Use of Cardboard Template.—A method often adopted for obtaining the correct profile of a moulding in wood or plaster, in which the detail is very small, is by means of a **cardboard template.** The moulding is carefully measured and plotted full

size on a sheet of stiff paper or cardboard ; its outline is then cut round carefully in such a manner that the cardboard forms a template that will exactly fit over the moulding originally measured. This template is applied to the moulding and further portions are carefully cut away until the outline on the cardboard exactly fits the moulding ; the cardboard can then be laid on a sheet of paper and the profile of the moulding traced round with a pencil, when a correct section of the moulding to full size will be obtained. At *a*, Fig. 15, is shown a moulding the correct profile of which it is necessary to obtain, and at *b* is shown the cardboard template which has been cut to fit into the moulding.

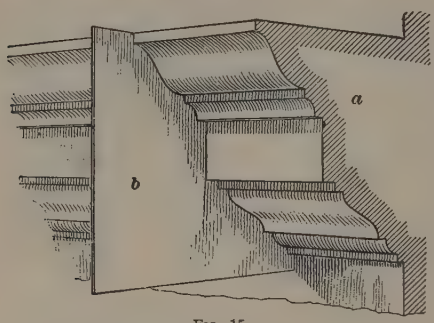

FIG. 15

30. Measuring a Cornice.—An illustration of the use of the lead strip is given in Fig. 16, where view (*a*) shows the profile of a stone cornice that is to be measured and view (*b*) the measured drawing of the same. To measure the projections of such a cornice as this, a plumb-line must be suspended from the edge of the top member of the cornice, as at *a*, and allowed to hang so that it will give a vertical line throughout the whole of the depth of the cornice as at *a b*. In Fig. 16 a 2-foot rule is shown, but the plumb-line is used to give the vertical line against which the 2-foot rule can be kept vertical. Dimensions are now taken from the plumb-line to all vertical faces of the moulding, as shown by the dimensions $4\frac{1}{4}$, 11, $13\frac{3}{4}$, $14\frac{1}{2}$, and $18\frac{1}{4}$ inches. These are carefully noted on the outline sketch, which should have been prepared previous to the taking of any dimensions.

The heights of the horizontal members must be measured from the top of the cornice. The first member, which consists simply of a vertical face 1 inch deep, can be quite easily measured, but

for the remainder of the heights a spirit level such as is shown in (*c*) must be used. One end of this level is tucked against the under side of the moulding to be measured, as shown at *c* in view (*a*), and is moved until it is truly level, when the dimension is measured from *a*, which is the top of the cornice, to the top of the level, as at *d*, when it will be found to read $17\frac{3}{4}$ inches.

A similar operation is gone through with the bottom of the moulding as at *e*; the level is placed against *e* and levelled up,

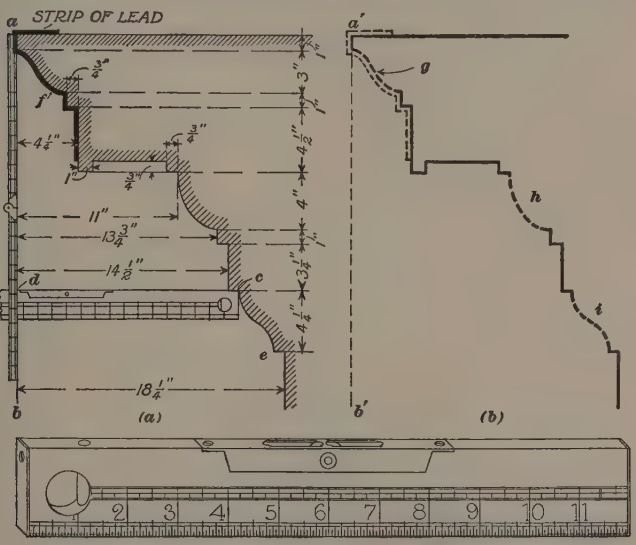

FIG. 16

when the dimension measured from the top of the level to the top of the cornice will be found to be 22 inches, so that if $17\frac{3}{4}$ inches is deducted from 22 inches the remainder will be $4\frac{1}{4}$ inches, or the exact depth of the lowest moulding in the cornice from *c* to *e*. In a similar manner all the mouldings of the cornice are measured. This will give the exact heights and projections for all the members of the cornice, but it will not give the profiles of the mouldings.

31. When plotted, the dimensions of the cornice as now taken will give the outline shown full in Fig. 16 (*b*). The dotted lines show the moulded members, the profiles of which have not yet been taken. At *f*, Fig. 16 (*a*), is shown a lead strip carefully pressed round the profile of the moulding. When it has been tucked into every corner and round the curve, it must be taken off the original and laid on to the drawing. So that the vertical and horizontal members of the cornice, as drawn, will coincide with the outline of the lead strip, the pencil may be carefully drawn round the lead forming the curve of the

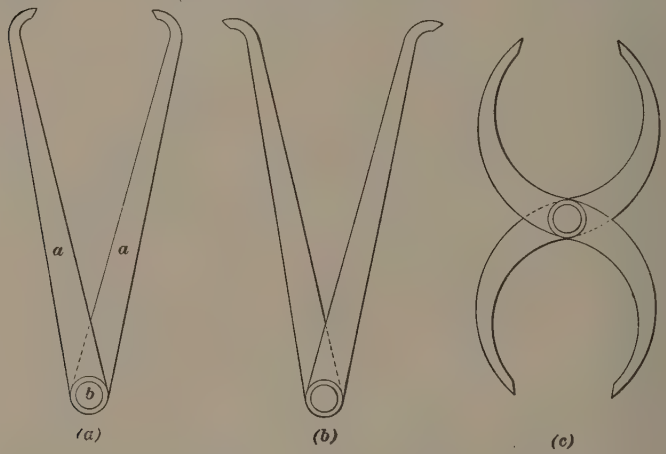

FIG. 17

moulding at *g* in (*b*). When transferring the lead strip from the cornice to the paper, great care must be taken not to bend the lead out of shape. In a similar way the curve of the mouldings at *h* and *i* may be transferred from the original, and thus the drawing of the cornice completed. In Fig. 16 (*b*), the line *a' b'* represents the plumb-line used in (*a*) for the purpose of measuring off the horizontal dimensions.

32. Use of the Calipers.—Classic mouldings may be easily measured by taking careful dimensions and using the lead strip and cardboard template, but Gothic mouldings are more difficult

problems. The chief feature of Gothic mouldings is that they are greatly undercut, by which means dark shadows are obtained with great effect. It is quite evident that the mouldings shown in Fig. 18 (*a*) could not be accurately gauged with the lead strip, for though it would be comparatively easy to beat the lead round the profile of the moulding and to its correct shape, it would be impossible to withdraw the lead, without distorting it, for the purpose of transferring the outline to paper. For

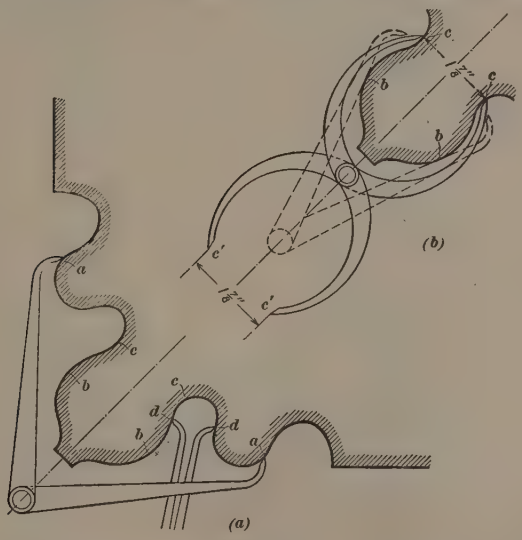

FIG. 18

correctly gauging undercut mouldings **calipers** must be used. This instrument consists of two arms *a*, *a*, Fig. 17 (*a*), turning on a joint *b*, and may be made of wood or iron. It somewhat resembles a pair of dividers with the points bent at an angle. The calipers mostly used are those shown in (*a*); often it is necessary to use this form with the arms reversed, as shown in (*b*). The instrument shown in (*c*) is used for measuring undercut mouldings.

33. In Fig. 18 (*a*) and (*b*) is shown the application of calipers to the measurement of undercut mouldings. In (*a*) is shown

a section through a Gothic arch moulding, where it is desired to obtain the dimension from *a* to *a*. The calipers shown in Fig. 17 (*a*) are opened out until their points just touch the two points *a*, *a* on the moulding; they are then carefully drawn from the moulding and laid on a 2-foot rule or 5-foot rod, when the dimension from tip to tip of the calipers will be exactly the same as the dimension from *a* to *a* on the moulding. The dimension from *b* to *b* in the same figure may be measured in exactly the same manner. To measure the hollow from *d* to *d*

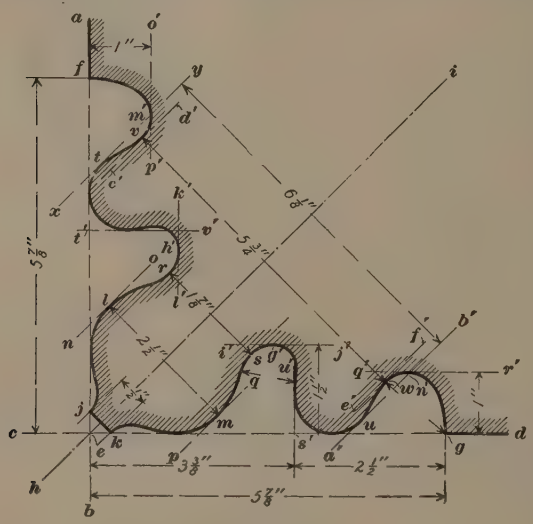

Fig. 19

the calipers are simply reversed, as shown, and opened until their points touch the points *d*, *d* on the moulding, the distance between which it is desired to measure. When they are withdrawn carefully, the measurement from tip to tip will be equal to the measurement from *d* to *d* on the moulding. But it is impossible with this instrument to measure the distance from *c* to *c*. As shown in the detail drawing (*b*), the calipers will not close enough for their points to touch the moulding at *c*, *c*, and if they did they could not be withdrawn over the projections

b, *b* so that the distance across their points might be measured; therefore the calipers shown in Fig. 17 (*c*) must be used. Their points are placed over the moulding until they touch the points *c*, *c* on the moulding, the distance between which it is desired to measure; as they cannot be withdrawn to measure the distance across their points, the measurement between the arms at the opposite ends *c'*, *c'* must be taken, which in this case is found to be $1\frac{7}{8}$ inches. With this form of calipers the distance between the points at one end always corresponds to the distance between the points at the opposite end, so that undercut mouldings of the type shown in Fig. 18 (*b*) should always be measured in this way.

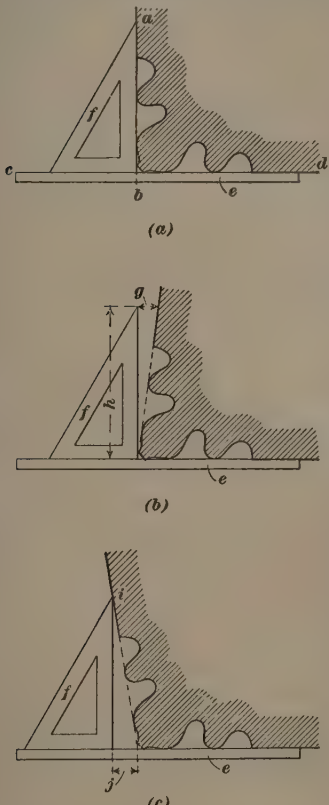

Fig. 20

34. Measuring Gothic Mouldings.—In Fig. 19 is shown a section of the same moulding shown in Fig. 18, with the necessary dimensions for drawing its profile marked on. First sketch out in pencil a rough section of the moulding on which the dimensions can be placed if the plotting is to be done at home; but if the plotting is to be done on the site, as it should be, the dimensions can be transferred direct to the finished drawing and need not be booked. A straightedge should be laid along the faces of the moulding, *a b* and *c d*, to ascertain whether all the faces of the curved mouldings are in one plane.

The angle formed between these two faces *a b* and *c d* should then be ascertained, but it will in all probability be a right angle.

To test this, lay a straightedge *e*, Fig. 20 (*a*), along the face *c d* and place upon it the set-square *f*; if the set-square just touches the face *a b* throughout its length, the angle is a right angle and the lines *a b*, *c d* may be plotted on the paper at right angles to one another. If the angle formed between the two faces is less than a right angle, the straightedge *e* and set-square *f* will appear in relation to the moulding as in Fig. 20 (*b*); in this case the angle may be determined by measuring the distances *g* and *h*. If, however, the angle is greater than a right angle, it may be obtained as shown in (*c*). The straightedge *e* should be laid against one face as before and the set-square *f* should be placed upon it and moved along until its top edge *i* touches the face of the moulding. The distance from *i* to the edge of the straightedge and the distance from the moulding to *j* should be measured, after which the angle can be plotted quite easily.

35. Having ascertained the angle between the two faces of the moulding, the lines *a b* and *c d*, Fig. 19, should be plotted upon the paper, intersecting at *e*. A straightedge should now be laid along the face *c d* and the distance from its face to the point *f*, in this case $5\frac{7}{8}$ inches, should be measured and plotted. The point *g* should be dealt with in a similar manner by laying a straightedge along the face *a b*. Bisect the angle *f e g* by the line *h i*. Measure the face *j k* and plot the dimension, $\frac{1}{2}$ inch, half on each side of the centre line *h i*; draw *j k* at right angles to *h i* until it cuts the lines *a b* and *c d* in the points *j* and *k*. Now, with the calipers, measure the distance *l m*, in this case $2\frac{1}{2}$ inches, and plot this half on each side of the centre line *h i*. Through the points draw the lines *n o* and *p q* parallel with *h i*, faintly and indefinitely, for they are to serve only as guide lines when drawing in the profile of the moulding. Measure the distance *r s* with the calipers and plot it half on each side of the centre line *h i*; draw through the points so formed guide lines parallel with *h i*. The distance between the points *t u* and *v w* should now be measured with the calipers, and guide lines *x y*, *a′ b′*, *c′ d′*, *e′ f′*, drawn parallel with *h i*, should be

put in, as these lines are tangent to the faces of the mouldings in the original.

The distance from the face of the straight-edge to g' will be found to be $1\frac{1}{2}$ inches; this should be plotted and the line $i'\,j'$ drawn through this point and parallel with $c\,d$. Measure from the face $a\,b$ to h' and through this point draw the guide line $k'\,l'$. In a similar manner measure from the face of the straightedge to the points m' and n' and

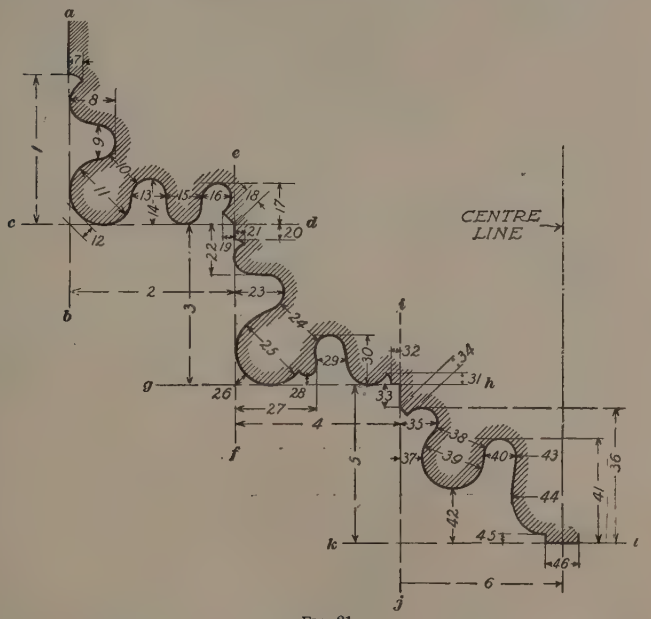

FIG. 21

draw through them guide lines $o'\,p'$, $q'\,r'$ parallel, respectively, with $a\,b$ and $c\,d$. The last dimensions necessary are those from e to s' and from e to t'; when these points have been found, draw $s'\,u'$ and $t'\,v'$ at right angles to $c\,d$ and $a\,b$, respectively, to act as guide lines when drawing in the moulding. The points having all been carefully measured and plotted, draw in the section of the moulding from f, making it tangential

to the guide lines previously measured and plotted. Great care must be taken to reproduce the curves in the original as far as possible. The guide lines may now be rubbed out; the remaining outline will then be a correct sectional detail of the original moulding.

36. In Fig. 21 is shown the section on one side of its centre line through a Gothic arch mould, and is more complicated to measure than the example given in Fig. 19; but the principles and methods for measuring and plotting apply equally well to the example given in Fig. 21 as to that in Fig. 19. It will be noticed that the members of this moulding group themselves up on a number of rectangular planes, as shown by the lines *a b*, *c d*, *e f*, *g h*, *i j*, *k l*, from which nearly all the important dimensions will be taken. Dimensions have not been given in this figure, but numbers are given instead. These indicate such dimensions as are necessary for plotting the section of this moulding, and the order in which each should be taken. Thus, the dimensions marked *1*, *2*, *3*, *4*, *5*, and *6* should be measured first, thereby ascertaining the plan of the rectangular forms suggested by the profiles; afterwards the detail of the moulding can be put in, by working in the order shown and on similar lines to that described for Fig. 19.

EXAMPLES OF MEASURED WORK

GOTHIC WINDOW

37. Method of Procedure.—The subject to be measured having been chosen, make a careful sketch elevation of it. This should be made geometrically and not in perspective, for the object is to make a simple drawing of the main features, in outline, on which the measurements can be marked; but no difficulty should be experienced in making this sketch. In this instance it is assumed that the finished drawing will be plotted at home, so great care must be exercised in taking the proper dimensions, for, should the subject be reached only after a considerable

journey, the finished drawing may be delayed because one or two dimensions have not been taken. It is equally important

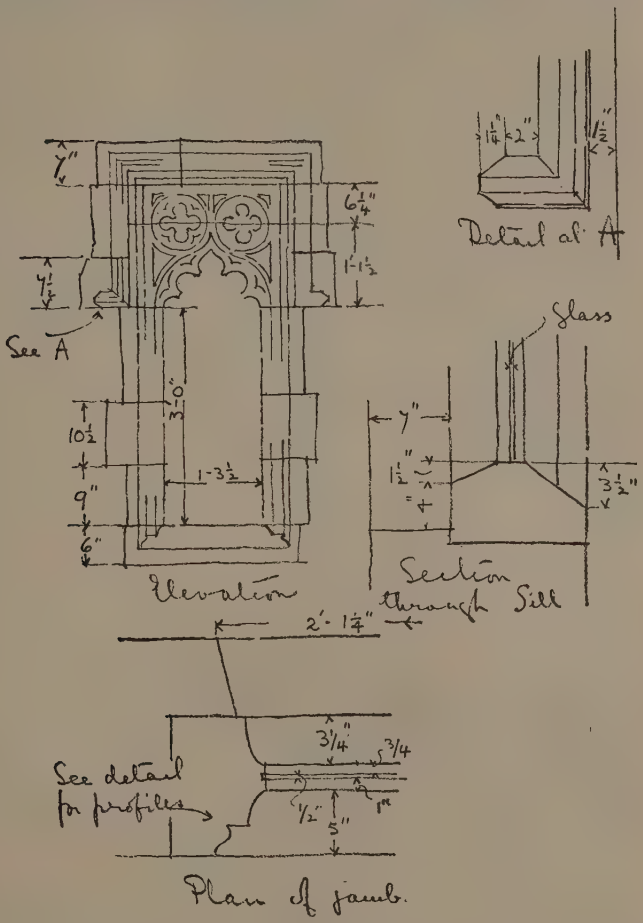

FIG. 22

to see that the dimensions are correctly marked on the sketch, or properly *booked*, as it is termed, with arrowheads terminating

the dimension lines to show exactly between which points the dimensions have been taken. The figures themselves must be written distinctly, and if a correction must be made to a figure already put down, the original figure should be crossed through and the revised one written above it. The importance of these precautions cannot be emphasized too strongly, as the time and care bestowed on the sketches and dimensions will be well repaid by the ease with which the finished drawing can be plotted.

38. Taking the Dimensions.—In Figs. 22 to 24 are shown reproductions of the pencil sketches, with the dimensions on same, from which the finished drawing shown in Fig. 26 was made. It will be noticed that the small geometrical sketch of the window, Fig. 22, is not in any way crowded with dimensions, only a few of the main ones being marked on it, as separate sketches of the more important parts are made to a larger scale. A detail sketch is, however, given in Fig. 22, showing the finish of the label mould *A* ; also a sketch section is given through the sill of the window, but it contains only the main dimensions. The plan of jamb is given simply to determine the glass line, but the detail of the moulding on the jamb is left to be sketched to a larger size and completely measured and figured up.

39. In Fig. 23 (*a*), (*b*), and (*c*) are shown details to a larger scale of particular portions of the window that need more detailed measuring. In (*a*) is shown the sketch section through the jamb on the inside of the window, with all the dimensions necessary to make a plotting to scale carefully placed on it. In (*b*) is shown the sketch of the outside jamb ; the cusping of the tracery is shown by dotted lines and all the figures are carefully noted. In (*c*) is the sketch section through the hood mould that runs round the head on the outside of the window.

40. In Fig. 24 is shown the pencil sketch of the tracery in the head of the window. This sketch is drawn much more carefully than that showing the tracery in Fig. 22, as that sketch was merely diagrammatical and indicated the position of the tracery in relation to the rest of the window. In Fig. 24 the sketch is

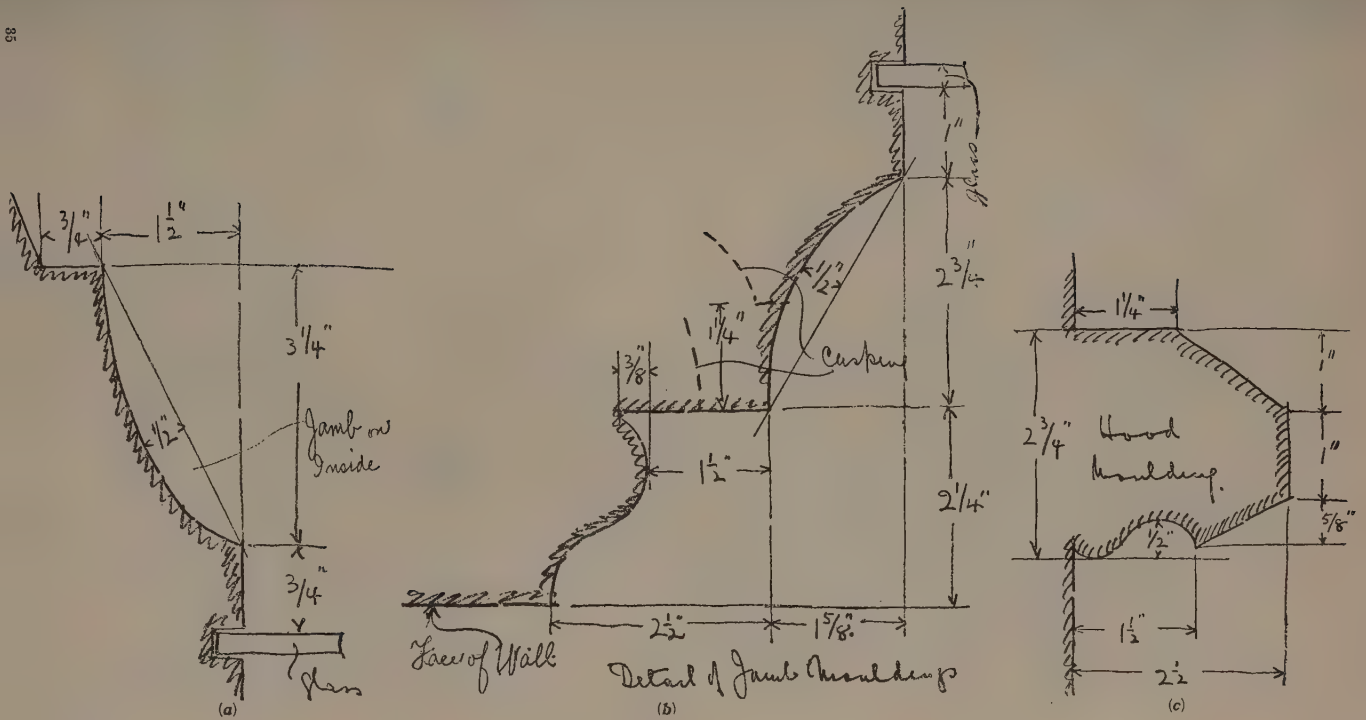
3/4"
1 1/2"
3 1/4"
1/2"
Jamb on Inside
3/4"
Glass
(a)
1"
Glass
2 3/4"
1/2"
1 1/4"
Cushion
3/8"
1 1/2"
2 1/4"
Face of Wall
2 1/2"
1 5/8"
Detail of Jamb Mouldings
(b)
1 1/4"
1"
2 3/4"
Hood Mouldings
1"
5/8"
1/2"
1 1/2"
2 1/2"
(c)

FIG. 23

intended to be fully detailed, so that in the finished drawing the tracery may be accurately put in place; for that reason the dimensions are placed on it. The lines of this tracery are set out

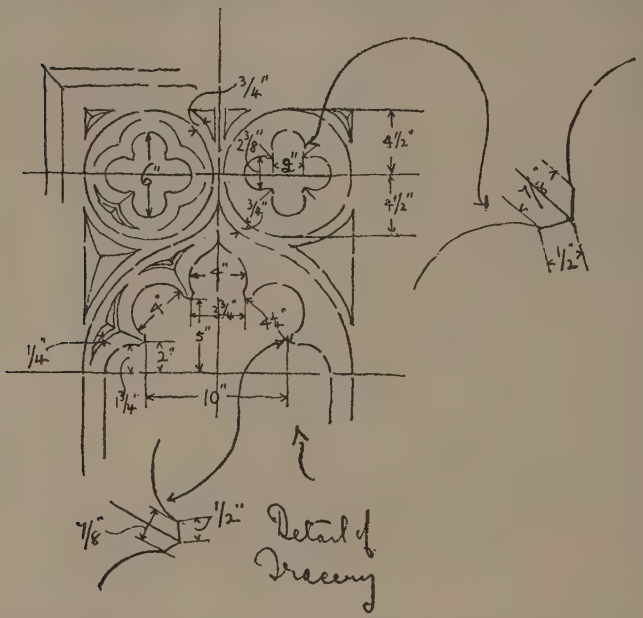

FIG. 24

geometrically; consequently, centre lines through the window and through the circular cusped panels have been carefully noted and measured, but the method to be adopted in plotting from these dimensions will be explained later.

41. Plotting the Dimensions.—The first thing to do when commencing the finished drawing is to plot the details of mouldings, etc., to full size, if possible; but if they are so large that they cannot be conveniently placed on to a sheet of drawing-paper they may be plotted to half or quarter size. In Fig. 25 is shown the finished drawing of the mouldings shown in Fig. 23 plotted from the dimensions taken from the actual example. Having obtained the correct profile of all the mouldings, etc., to

a large scale, the complete finished drawing to scale may be commenced.

In Fig. 26 is shown the finished drawing of the window. To obtain this, the plan should be drawn first. The jamb *a* may be set out from the sketches taken to whatever scale it has been determined to use, and the mouldings on its face may be drawn from the dimensions for the full-sized detail already set out in Fig. 25. The jamb *b* should be set out in a similar manner at a distance of 1 foot $3\frac{1}{2}$ inches from *h* to *h'*, as shown, this distance being determined from the dimension shown on the elevation in Fig. 22. The plan can now be completed as shown. Next, the section through the sill should be drawn from the sketch and dimensions given in Fig. 22 and the width shown on the plan already drawn in Fig. 26. Now begin the elevation of the window by projecting the top line *c d* of the sill across from the section. A dimension of 3 feet should be measured at right angles to *c d*, as shown in the sketch in Fig. 22, to obtain the springing line of the tracery; this springing line should be drawn in parallel to *c d* in Fig. 26. Now, on the elevation run up the lines of the jamb mouldings from the points *e*, *f*, *g*, and *h* on the plan, checking them with the dimensions given on the sketch details to a larger scale; and in a similar manner run the lines on the other side of the window.

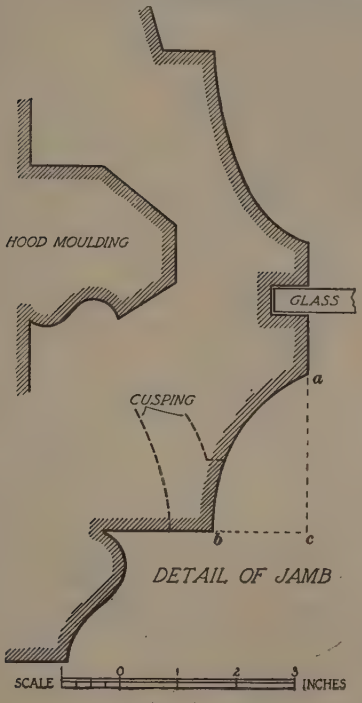

FIG. 25

It will be noticed that the jamb moulding stops, or dies, into

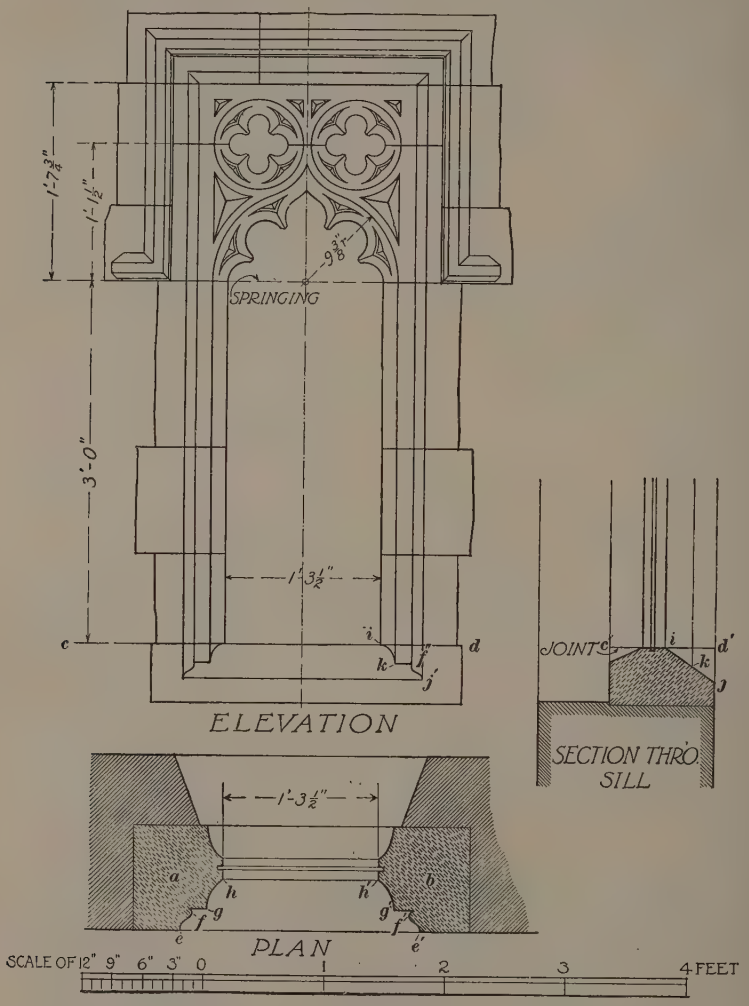

Fig. 26

the splay *i j* shown in the section through sill, and the elevation

of the jamb moulding at this point must be determined, so that the elevation may be completed. The line running through the point h' on the plan stops on the joint line $c'\ d'$ of the section, so that the elevation of the line running through h' will stop on the line $c\ d$ of the elevation at the point i. The elevation of the line running through g' on the plan is stopped at the point k on the splay of the sill shown in the section, so that through k draw a line parallel with $c\ d$ until it cuts the elevation of the line running through g' on the plan at k in the elevation. As the line running from g' to f' on the plan is parallel with the face of the wall, it will be represented by a horizontal line on the elevation, so draw through k the line $k\ f''$ until it cuts at f'' the line run up from f' on the plan. The point e' on the plan is at the face of the wall and dies on to the splay of the sill shown in section at the point j, so that the line in the elevation drawn up from the point e' on the plan will stop at the point j' on the elevation run across from the point j on the section. The mouldings $i\ k$ and $f''\ j'$ on the elevation can now be drawn in, and the elevation of the stopping of the moulded jamb on the splayed sill will be complete. In a similar manner the jamb on the other side of the window may be finished. The joints in the elevation, as dimensioned in Fig. 22, may be drawn in and the lower portion of the finished elevation completed.

42. More difficulty will be experienced with the upper part of the window, but since the tracery is all set out on geometrical lines, no difficulty that cannot be overcome should present itself. In Fig. 27 is shown a detailed method of setting out the tracery in the window head, and for practice this tracery should be set out on a separate sheet of paper before the finished drawing is commenced. On a piece of paper draw the line $a\ b$ to represent the springing line, and $c\ d$ at right angles to it to represent the centre line of the window. Above the line $a\ b$, at a distance of 1 foot $1\frac{1}{2}$ inches and parallel with it, draw a line $e\ f$ representing the centre line of the circular cusped panels as shown in Fig. 22. The point g, Fig. 27, where the centre line of the window cuts the springing line of the tracery will give the centre for the main curves of the lower portion of the tracery. It is already known

from the dimensions taken that the centres for the circles enclosing the cusping at the upper portion of the window are somewhere on the line *e f*, but their exact positions must be determined. By referring to the sketch in Fig. 24, it will be seen that a dimension of $\frac{3}{4}$ inch is shown on it, being the width of the plain face between

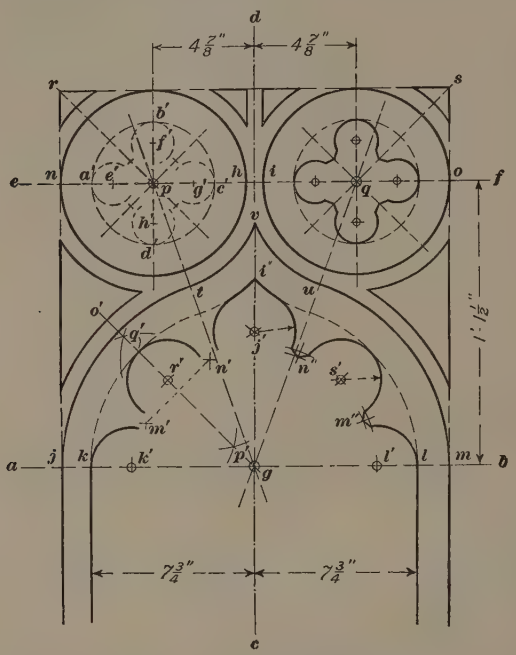

DIAGRAM SHOWING METHOD OF SETTING OUT TRACERY

Fig. 27

the two circles, so on the line *e f* set out a distance of $\frac{3}{8}$ inch, which is half the dimension of $\frac{3}{4}$ inch before obtained, on each side of the centre line *c d*, as shown at *h* and *i*, giving one point on the circumference of each circle. Now set out, on the line *a b*, the points *j*, *k*, *l*, *m*, which can be obtained by reference to the sketch elevation in Fig. 22 and the detail dimensions plotted

in Fig. 25. The points *k* and *l* are 1 foot $3\frac{1}{2}$ inches apart from one another, as shown on the elevation in Fig. 22; so set off $7\frac{3}{4}$ inches, as shown in Fig. 27, on each side of the centre line *c d*.

From *k* and *l*, set off dimensions to scale equal to *c b*, Fig. 25, which will give the elevation of the moulding *a b* in the same figure. Now, on Fig. 27, draw the lines *j n* and *m o* at right angles to *a b* until they cut the line *e f* at the points *n* and *o*; the points *n* and *o* so found will be other points on the circumference of each of the two circles. Bisect *n h* and *i o* at the points *p* and *q*, when the points so found will be the centres from which the two circles may be drawn in. Draw the line *r s* tangentially to the two circles and then produce *j n* and *m o* until they cut this line in *r* and *s*. Join *p* and *g*, also *q* and *g*, by a dotted line as shown. With *g* as centre and radius *g j*, or *g m*, draw the curves *j t* and *m u* until they cut the dotted lines *p g* and *q g* in the points *t* and *u*; with *p* and *q* as centres draw the curves *t v* and *u v* meeting on the centre line *c d* at the point *v*. If the curves and setting out have been done correctly, the distance between the curves *t v* and *u v* and the circumferences of the two circles drawn with centres at *p* and *q* should be $\frac{3}{4}$ inch, as shown on the sketch in Fig. 24.

43. The main lines of the tracery have now been obtained, so it only remains to fill in the cusping. Reference to Fig. 24 shows that the extreme distance between the inside faces of the cusping in the two circles is 6 inches, so with *p* and *q* as centres describe two circles having a radius of 3 inches, as shown by the dotted lines cutting the horizontal and vertical diameters of the circles in Fig. 27 at *a'*, *c'*, *b'*, and *d'*. Again referring to the sketch in Fig. 24, it will be found that the diameter of the four small circles forming the cusps is $2\frac{3}{8}$ inches; so from the points *a'*, *b'*, *c'*, *d'*, Fig. 27, measure distances *a' e'*, *b' f'*, *c' g'*, *d' h'*, equal to $1\frac{3}{16}$ inches, or the radius of the small circles. The points *e'*, *f'*, *g'*, *h'* will then be the centres from which the small circles, shown dotted, can be turned in tangential to the larger circle at the points *a'*, *b'*, *c'*, *d'*. It is shown in Fig. 24 that the points of the cusps are 2 inches apart, so the small circles should be turned in complete from the centres *e'*, *f'*, *g'*, *h'*, in pencil, and

lines parallel to the horizontal and vertical diameters of the circle having a centre at *p* should be drawn, at a distance apart of 2 inches, 1 inch on each side of the line forming the diameters of the circle. Where these lines cut the circumferences of the smaller circles will be the points where the curve of the smaller circles is to stop, and where the apex of the cusp is to be formed, in each case, as shown. The cusping in the other circle is drawn in a similar manner.

44. The cusping to the lower portion of the head of the window is drawn in a manner very similar to that just described. From the centres *g*, *p*, and *q*, Fig. 27, dotted lines *k i'*, *l i'* are drawn, giving the line to which the back faces of the cusps are tangent. It will be seen that the centres for the top and for the two lowest cusps are on the centre line *c d* at the point *j'* and on the springing line *a b* at the points *k'* and *l'*. Fig. 24 shows that the radius of the lower cusps is $1\frac{3}{4}$ inches; so set off *k k'* and *l l'*, Fig. 27, equal to $1\frac{3}{4}$ inches. The diameter of the top cusp is 4 inches, as shown in Fig. 24; so with a centre *j'* describe a circle having a radius of 2 inches and tangent to the curves *i' k* and *i' l*. The points at the tips of the cusps *m'*, *m''*, from Fig. 24, are found to be 2 inches above the springing line and 10 inches apart. So in Fig. 27 set up a line 2 inches above and parallel to *a b*. At a distance of 5 inches from each side of the centre line *c d*, and parallel with it, draw two lines cutting the previous lines at *m'* and *m''*. The points *n'* and *n''*, 5 inches above the springing line and $3\frac{3}{4}$ inches apart, as shown on the sketch in Fig. 24, may be found in a similar manner. Join *m'* and *n'* by a faint line and bisect the line *m' n'* by the line *o' p'*. From the point *q'*, where the line *o' p'* cuts the curve *k i'*, draw *q' r'* equal to 2 inches; the point *r'* will be the centre for the middle cusp as its diameter is 4 inches, as shown on the sketch in Fig. 24. The centre *s'* is found in a similar manner. Having found the centres for all the cusps, it will be quite an easy matter to complete the cusping in accordance with the sketch in Fig. 24 on similar lines to those described for the cusping in the two circles in the head of the window. The finish to the points of the cusps is clearly shown in Fig. 24 by the two enlarged sketches.

45. When this tracery has been accurately set out to a large scale, and the principles of working out have been mastered, the finished drawing, Fig. 26, may be completed; but great care must be taken in drawing in the tracery on this drawing, for accuracy in working is of the first importance. After the tracery has been drawn in, proceed to complete the drawing by measuring up from the springing line a dimension of 1 foot $7\frac{3}{4}$ inches, obtained by adding together the two dimensions 1 foot $1\frac{1}{2}$ inches and $6\frac{1}{4}$ inches from Fig. 22; this will give the top joint line of the head of the window and should be drawn across parallel with the springing line. The lines representing the elevation of the moulding at *f* and *f'* on plan, Fig. 26, should be checked with the original dimensions, and run up until they cut this joint line as shown. Similar lines must be run up from the points *e* and *e'* on plan and round the top of the window over the joint line as shown in the elevation in Fig. 26. The only work now remaining to be done on the drawing is the putting in of the stone joint lines, which can be easily done from the sketch in Fig. 22, and the drawing in of the hood moulding, which is shown in detail in Fig. 23 (*c*) and the finish of which is shown in the *Detail at A*, Fig. 22. The drawing may now be carefully inked in or left in pencil as preferred.

GEORGIAN DOORWAY

46. Method of Procedure.—The second subject to be measured and plotted is the Georgian doorway shown in Fig. 28, which is a fine specimen of that type, is of considerable beauty, and is executed wholly in wood. Although at first sight this doorway may appear somewhat difficult for a beginner to measure, it will be found, if the task is undertaken patiently and methodically, to present no more difficulties than a subject apparently more simple, and will not require any more knowledge than has been obtained if the instructions given have been mastered. The method of procedure is very similar to that for measuring the Gothic window, but great care should be taken in making the preliminary sketches and taking the dimensions. In Fig. 29 is shown a reproduction of the preliminary geometrical sketch made by the artist who measured this doorway. No attempt

was made to show the mouldings or carving carefully, for these will form the subject of more careful and larger sketches. The

Fig. 28

doorway being symmetrical, time and labour were spared by

drawing in only one-half of the elevation, which, however, should be done with general observance of the relative proportions

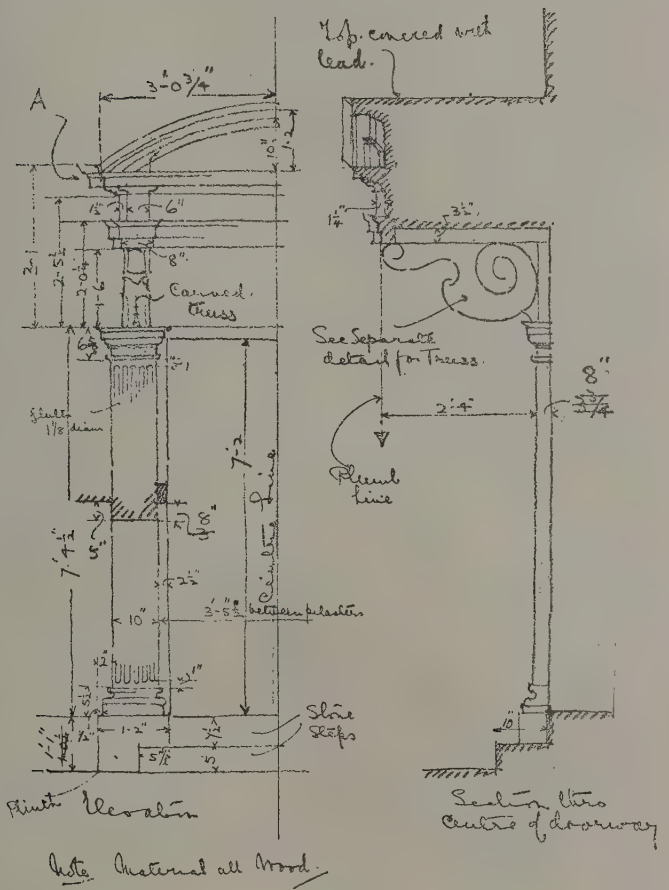

Fig. 29

of the individual parts ; for though any distortion in the original sketch will be ultimately corrected by the measurements taken,

the outline sketch should be as nearly in proportion with the original as possible.

47. Taking the Dimensions.—The sketch having been completed, the dimensions must be taken and clearly indicated on it. A pair of steps or a short ladder will be required to reach some of the dimensions. A good method to adopt in such a case as this is to go over the sketch carefully and determine just which dimensions must be taken to enable the finished drawing to be plotted accurately, and then mark each position with a dimension line, thus <— —>. The arrowheads will show clearly between which points the dimensions are required. It will be found that there will be less chance of omitting important dimensions if this system is adopted. All dimensions must be taken systematically; for instance, all the widths should be taken first, then the heights, and finally the main projections.

The sketch shown in Fig. 29 embodies all the dimensions that will be required for the setting out of the elevation, plan, and section of the doorway. The first dimensions to be taken are the width of the doorway opening, 3 feet $5\frac{1}{2}$ inches, and the widths of the pilasters, 10 inches, which are recorded as shown. The widths of the base to the pilasters and of the projecting cornices over the pilasters should then be measured and booked. The heights should next be taken, as shown; first the doorway opening and rise of the steps, then the main heights of the pilaster and its base. After these the heights of the cornice should be measured. It will be noticed that all the dimensions showing the main heights of the members composing the cornice are measured from a common base line, namely, the top of the cap of the pilaster.

This method is always preferable to measuring each group of mouldings separately, for there is then less chance of any error being caused by one of the sets of mouldings differing slightly from the dimension shown. The section should now be carefully sketched in, simply in outline, and the main dimensions measured and placed on the sketch as shown. The projection of the hood over the doorway is obtained by dropping a plumb-line from the face of the architrave, and measuring back to the face

of the pilaster and then measuring back to the door frame, a distance of 8 inches as shown. It will be noticed that this distance was first booked as $3\frac{3}{4}$ inches, but was altered to 8 inches by scratching through the original dimension rather than by rubbing it out.

48. Details.—In Fig. 30 is shown a sheet of sketch details of mouldings with the dimensions carefully placed on them. The section of the cap and base to the pilasters should first be drawn, as nearly as possible, in proportion to the original, and all the projections to the most important faces should be measured. In the case of the mouldings of the cap, a plumb-line should be suspended over the top member and allowed to hang over the face so that the distance to all the members can be measured back from this vertical line, as shown in Fig. 30. The heights of each member should then be measured with the 2-foot rule, using the spirit level, as suggested in Art. **30**, where necessary. The calipers may also be used if the measurement can be obtained more nearly accurate by them. The base should be measured in a similar manner, both as regards heights and projections, when the final result should appear as in the sketch in Fig. 30.

The next detail to be measured is that of the entablature, consisting of architrave, frieze, and cornice, with pediment mouldings, as shown in Fig. 30. The whole method of procedure is exactly similar to that given in Art. **30**, and by careful use of the plumb-bob, spirit level, and 2-foot rule, accurate results should be easily obtained. The mouldings in this case are too small for the successful use of the lead strip, but if extreme accuracy is required their profile may be cut in cardboard. If the drawing is plotted on the spot, all the dimensions shown in Fig. 30 need not be booked, but may be transferred direct to the finished drawing. The carved truss shown in Fig. 31 is the subject of a separate sketch and must be drawn sufficiently large to indicate the detail clearly and with sufficient space for the figures. Two views are necessary, side and front, and each should be drawn in bare outline, for a detail is required, not a picture. The plumb-line is again needed to obtain the projections of various salient points in front of the face of the pilaster. From the

plumb-lines, as shown on the sketch, dimensions are taken to

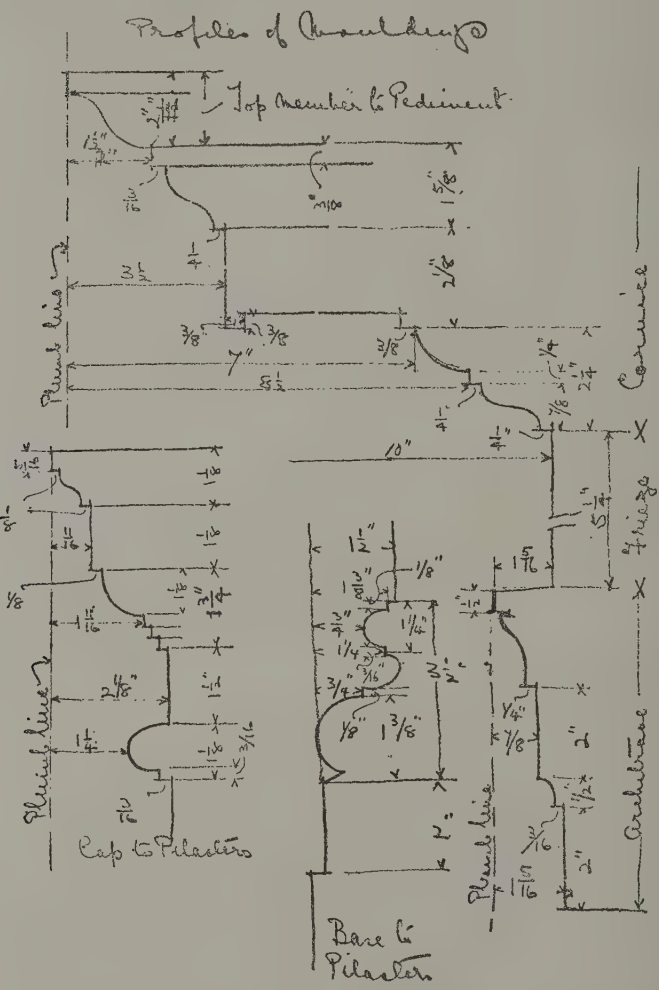

Fig. 30

various positions on the truss, and the chief lines of the truss are

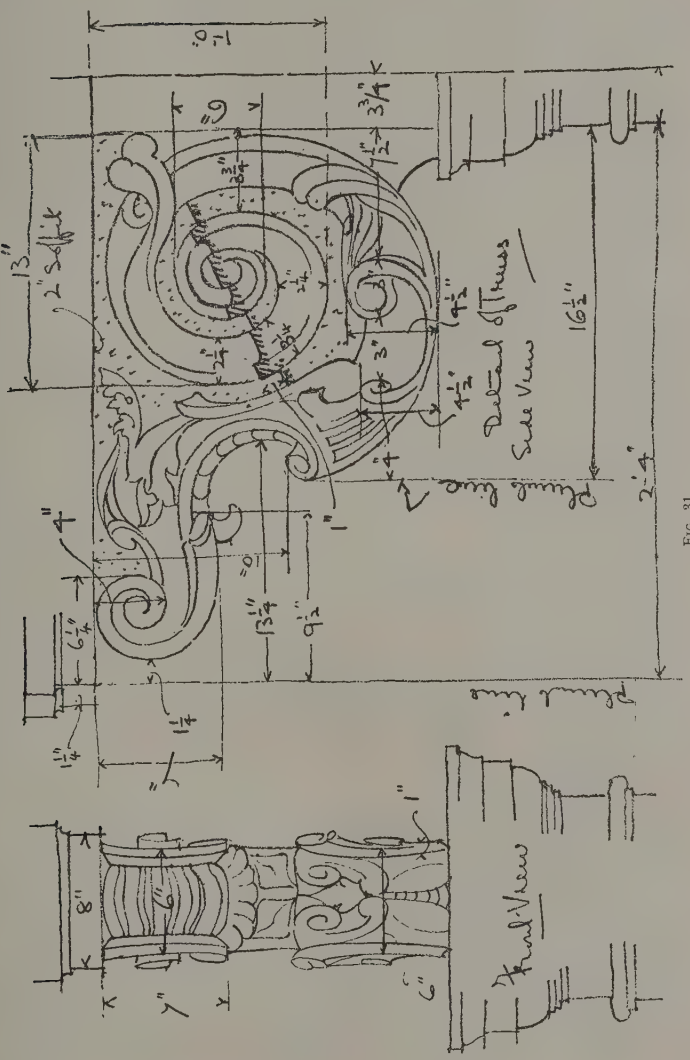

Fig. 31

measured and booked for the finished drawing. The cap of the pilaster is sketched in so that the position of the truss in relation to the cap may be determined, as also the lower members of the architrave to the cornice. A section of the volute is sketched, and the projection from the face of the truss measured, as also the detail of its members. In a case like this, the camera will be found exceedingly useful for supplementing the information contained in the sketch book, but the photograph should not be used for copying from.

49. Plotting the Dimensions.—In Fig. 32 is shown the plotting of the full-sized details which should be completed before any of the general drawings are commenced. It should be quite easy to plot these mouldings from the instructions already given. It will be noticed that the mouldings are plotted in an opposite direction to that shown on the original sketch, Fig. 30, but the only reason for doing this is to obtain a better appearance on the finished sheet. The cornice can be plotted by commencing at the top member *a b*, which should be drawn 2 inches deep, as shown in Fig. 30. A faint vertical line should be drawn down the paper, to represent the plumb-line shown in Fig. 30, from which the various horizontal dimensions given may be set off. The vertical dimensions should be measured down from *a*, when the profile of the cornice can be easily completed. The frieze need not be drawn in full, but it can be broken, as shown, and its depth $5\frac{1}{4}$ inches indicated by a figure and dimension lines. The top member of the architrave from *c* to *d* should be measured off, $1\frac{5}{16}$ inches, as shown in the original sketch. From the point *d* a vertical line may be dropped to represent the plumb-line in the original, from which all the horizontal dimensions can be measured off. The vertical dimensions can be measured down from *c d* and the architrave completed, as shown in Fig. 32, from the sketch and dimensions in Fig. 30. Care must be taken to show the slight slope on the top of the architrave mouldings, probably made so that any wet lodging there may easily drip off.

The next mouldings to be plotted are those of the cap and base of the pilaster. These can be drawn from the sketch and dimensions given in Fig. 30 by starting at the top member *e*, Fig. 32, in

the case of the cap, and dropping a vertical line to represent the plumb-line from which the horizontal dimensions will be obtained, as shown in Fig. 30. The horizontal and vertical

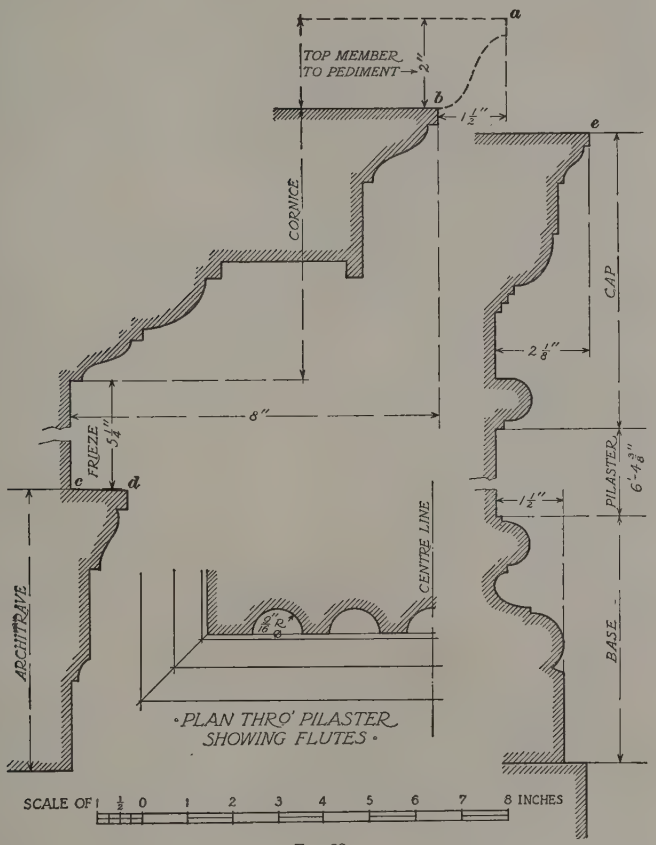

Fig. 32

dimensions can now be set out and the moulding completed. The pilaster itself is not drawn in full, but is broken off and a dimension 6 feet $4\frac{3}{8}$ inches inserted in the detail to show its

length ; this dimension is obtained from Fig. 29. The base is

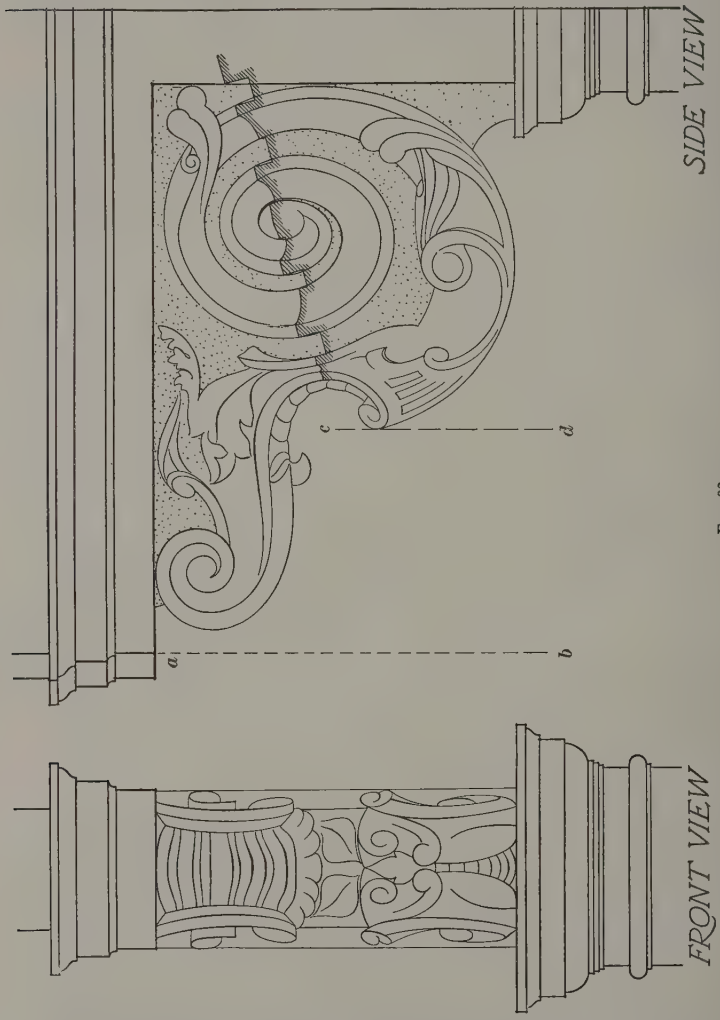

FIG. 33

$5\frac{1}{2}$ inches high and the cap $6\frac{5}{8}$ inches, so the height of the pilaster

between cap and base will be 7 feet $4\frac{1}{2}$ inches less 1 foot $\frac{1}{8}$ inch, or 6 feet $4\frac{3}{8}$ inches. The base is drawn in a similar manner to the cap, and from the sketch and dimensions given in Fig. 30. The plan through the pilaster is next drawn. From Fig. 29 it will be found that the pilaster is 10 inches wide, and as it is similar on both sides of its centre line there is no need to draw more than half its plan. This is drawn as shown in Fig. 32, it being ascertained from Fig. 29 that there are five flutes in its width, and each flute is $1\frac{1}{8}$ inches diameter or $\frac{9}{16}$ inch radius, as shown in Fig. 32.

50. In Fig. 33 is shown the finished drawing of the carved truss, the sketch of which, with the dimensions marked on it, is shown in Fig. 31. The members of the cap and architrave mould can be drawn in accurately from the dimensions plotted in Fig. 31 ; the carving should then be very carefully drawn in from the particulars given in Fig. 31. The truss has been drawn to a large scale, as it is of sufficient importance in the original design to merit a separate drawing to a large scale, full size if possible, being made. The front and side elevations are drawn and a section across the volutes is given. The dotted lines shown at *a b* and *c d* represent the plumb-lines in Fig. 31 and are simply put on the finished drawing to aid in setting out the dimensions ; they can be rubbed out when the drawing is completed. The drawing has been purposely kept free from shading so as to give a clear idea of the lines of the carving rather than a pictorial representation of the truss.

51. The finished drawing, to scale, of the complete doorway may now be commenced, as shown in Fig. 34. For a doorway of this size, the scale of 1 inch to 1 foot is very convenient and was used in the original plotting, but it has been considerably reduced in the process of reproduction. Space has been saved by plotting only one-half of the doorway, but sufficient particulars are given in the sketches to draw the complete doorway, if desired. The centre line should be drawn first, and half the width between the pilasters marked off from it. Lines are then drawn vertically to represent the pilaster, and horizontal lines are drawn from the dimensions taken to mark the position of base,

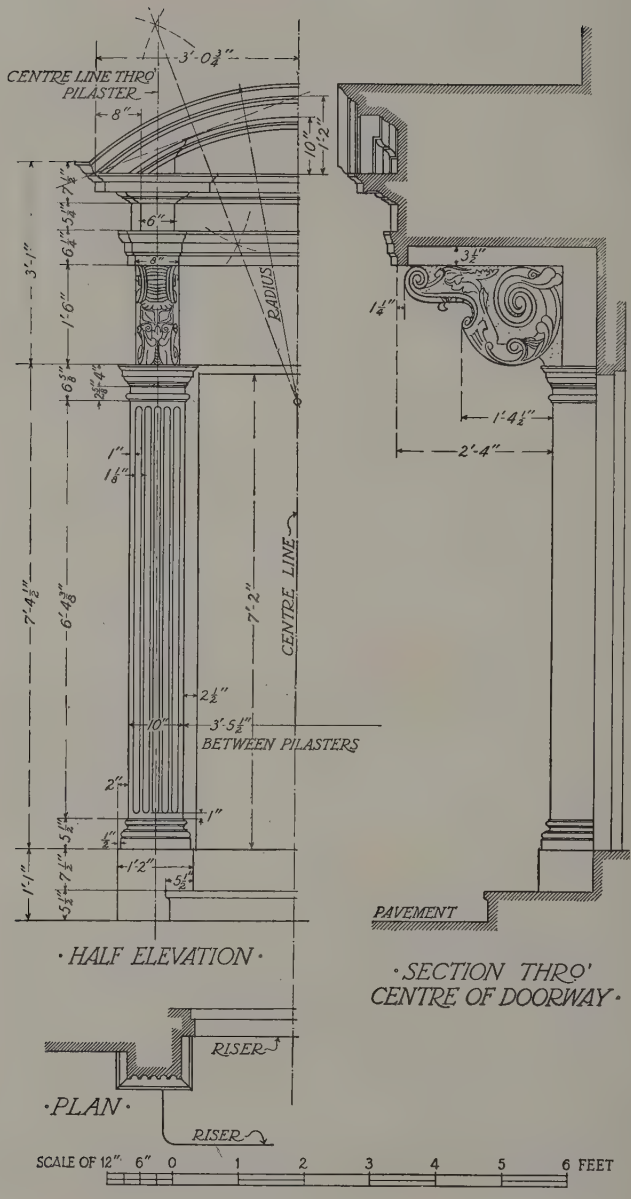
CENTRE LINE THRO' PILASTER
3'-0¾"
8"
10"
1'-2"
6"
8"
RADIUS
3'-1"
1'-6"
7'-4½"
6'-4⅜"
7'-2"
CENTRE LINE
1"
1⅛"
2½"
10"
3'-5½"
BETWEEN PILASTERS
2"
1"
1'-2"
5½"
1'-1"
·HALF ELEVATION·
3½"
1¼"
1'-4½"
2'-4"
PAVEMENT
·SECTION THRO' CENTRE OF DOORWAY·
RISER
·PLAN·
RISER
SCALE OF 12" 6" 0 1 2 3 4 5 6 FEET

FIG. 34

cap, cornices, etc. A comparison of the sketches with the finished drawing will make this clear and obvious. No difficulty should be experienced in setting out and completing this drawing from the sketches and dimensions taken on the site, if the preliminary instructions have been carefully studied.

The only difficulty that may be experienced is in setting out the curved pediment over the doorway, so the method of doing this is briefly explained. In Fig. 35, a dimension of 3 feet $\frac{3}{4}$ inch set off from the centre line is given. This was obtained from the sketch shown in Fig. 29, and represents the dimension taken from the centre line of the doorway to the projection of the cornice *a*, Fig. 35, below the top member, or cyma. There is also given the dimension of 1 foot 2 inches, which is the height of the rise *c b* of this same member above the cornice in the centre of the doorway at the level *a*. Join *a b* and bisect the line at the point *d*. At this point draw *d e* at right angles to *a b*, cutting the centre line of the doorway in the point *e* ; the point *e* will be the centre from which the curve of the pediment is struck. To find this centre on the finished drawing, Fig. 34, a similar process should be gone through, and the necessary lines for finding the centre can be rubbed out when the drawing is complete.

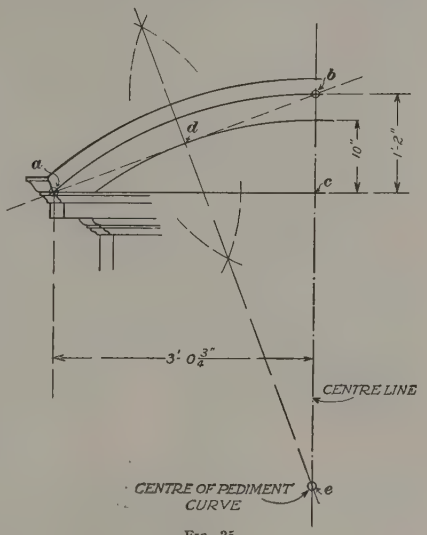

Fig. 35

52. In Fig. 36, a finished drawing of the side elevation of the pediment and the manner in which it finishes against the

wall face *a b* is given. It is drawn to the same scale as that shown in Fig. 33. There is no need to draw the truss carefully in this drawing, as its only purpose is to show the finish against the wall face, and the fact that the pediment is covered with lead; for this reason the position of the truss has been simply indicated. Having completed the plotting of the doorway in Fig. 34 in pencil, it may be either inked in or neatly outlined in pencil. The dimensions should then be put in and the printing completed. The two examples given should suffice to indicate the principles and methods of procedure in making measured drawings.

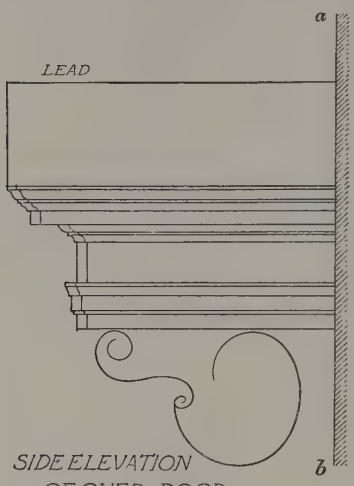

Fig. 36

PICTORIAL SKETCHING

PRELIMINARY INSTRUCTIONS AND EXAMPLES

INTRODUCTION

53. Pictorial sketching, while in a sense representing a less serious side of an architect's studies, in that it is to an enthusiast a really enjoyable means of gaining information and spending the time on a holiday, is none the less important. While the principal idea is that of making a picture, the benefit to be derived from the work by gaining a knowledge of design and the principles of proportion must never be lost sight of. In this type of sketch the artistic faculties are called into use, and a keen appreciation of light and shade and composition is essential.

At the outset, avoid haste and practise deliberation, for every stroke of the pencil ought to be a direct and necessary contribution to the result. The subject chosen should be represented by as few lines as possible, rigid economy of line being one of the maxims always to be borne in mind. Discouragement is sure to be felt at the beginning, when others are seen dashing off a sketch with a few swift and accurate sweeps of the pencil; but speed is only acquired by much hard work and practice, and it should rather be encouragement than a discouragement to know that in all probability a similar state of proficiency may be attained by conscientious application and hard work.

A knowledge of perspective and freehand drawing is essential to the production of a satisfactory sketch. The first attempts will no doubt be disappointing, for the sense of proportion will not be easy to acquire, and the perspective may present difficulties; but it should be borne in mind that all horizontal lines below the level of the eye incline upwards as the object appears to recede, and all lines above the eye level incline downwards.

EXAMPLES

54. The first sketches should be kept clear and open, somewhat after the style of the church tower in Fig. 37. This sketch was made with a B pencil on smooth cartridge paper, and has just sufficient indication of detail to make it architecturally interesting without presenting a laboured appearance. Just sufficient detail is put in to indicate the material in which the tower was built, and although this is only suggested by the slightest outline, there can be no mistaking the fact that the material is stone. It is a quick sketch, and just such a one as would be made on a sketching tour when only a short time could be devoted to a single subject. Fig. 38 illustrates a similar type of sketch, suggestive and simple in treatment, but showing less detail than that in Fig. 37. Particular note should be made of the way the detail in the tower is suggested, both in the balustrade on top of the tower and in the windows, merely by the insertion of a few well-placed dots. Sufficient is given to indicate what is meant quite clearly, but the sketch does not look in any way

laboured. Such sketches are the more intelligently rendered as the knowledge of the detail indicated by so few lines is acquired.

A more difficult subject is shown in Fig. 39, where a sketch of Lincoln Cathedral from the south-west is given. Here

Fig. 37

the method of indicating detail by suggestion has been carried almost to the extreme. The subject is at a considerable distance from the eye, and the aim has been to render a delicate and suggestive sketch, while preserving the architectural interest,

a result which has been well accomplished. The deeper touches at the centre of the picture concentrate the interest just where it is most wanted, and yet they in no way detract from what is the chief feature of the picture, the Cathedral itself.

55. An effective and often-used method for emphasizing shadows is to cover them with a diluted wash of lamp-black,

Fig. 38

but care is necessary in applying the wash to preserve the texture of the pencil lines. The pencil sketch should first be placed in a bath of water to fix the lead and the wash applied before the paper is quite dry. Washes should be sparingly used and always kept subordinate to the pencil work, although when intelligently applied they greatly improve the appearance of a

pencil sketch. In Fig. 40 is shown a rapid pencil sketch of a village street in St. Malo, France. The shadows are covered

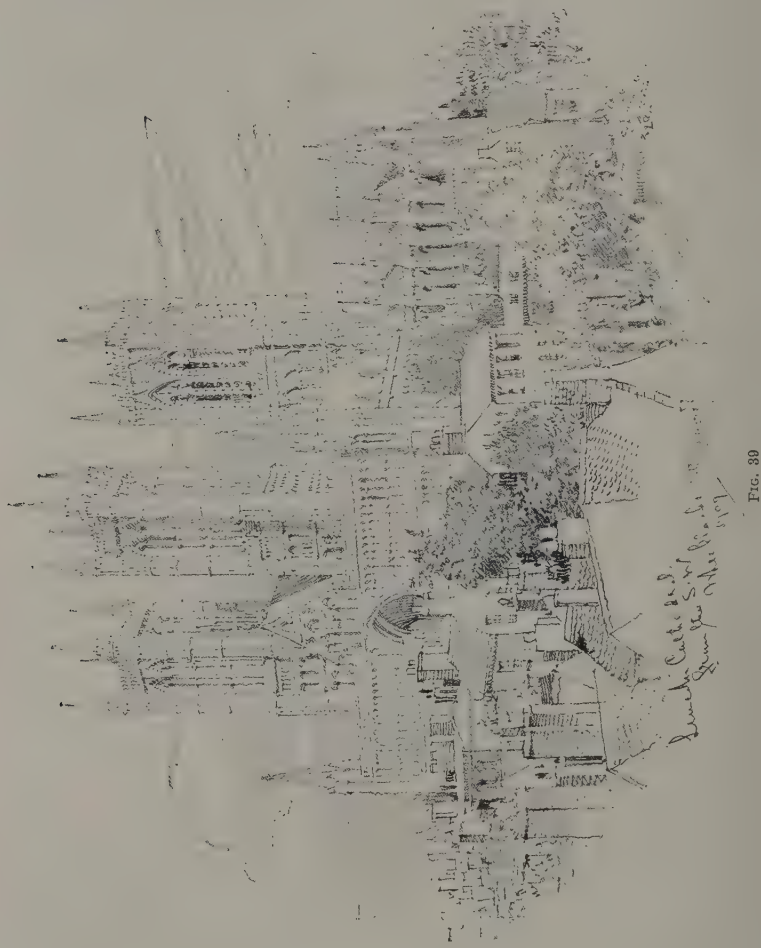

Fig. 39

with a light wash, imparting in an instant a force to the sketch which would otherwise be lacking. The wash emphasizes the

particularly sunny effect of the scene in a manner that cannot

Fig. 40

be otherwise accomplished, except by the labour spent in working in the shadows in pencil. The style of the sketch shows

Fig. 41

that it is of a quick nature, probably made on a holiday or sketching tour, where much time could not be spent on each

FIG. 42

subject. The quick method of washing in the shadows, and thus considerably increasing the effectiveness of the sketch, has therefore been used with great success.

56. In Fig. 41 is shown a sketch of some old houses at Rouen, where the effect that can be obtained by washing in shadows is even more marked than that shown in Fig. 40. This sketch is of a bolder and more deliberate type than that shown in Fig. 40, and more time has been spent on its execution. Particular note should be made of the technique in this sketch, and how clearly the different materials are indicated. For instance, there is no mistaking which is a stone wall surface and which is plaster; the woodwork of the half-timbered house is also clearly marked. Vigour and brilliancy are given to the sketch by the dark pencil touches so well put in, evidently with a BB or BBB pencil, and the whole composition is cleverly completed by the addition of the lamp-black washes placed upon it, quickly, yet very effectively, deepening and giving transparency to the shadows.

In Fig. 42 is shown yet another type of sketch, which, being a general view rather than a sketch of detail, demands a somewhat delicate treatment. This sketch was drawn entirely with an HB pencil on smooth cartridge paper, and clearly shows what a range of tone can be obtained from one pencil in an artist's hand. The sketch is in no sense laboured, as will be seen at once on looking at the treatment of the windows and dormers, which are in most cases merely suggested by a few lines, the treatment of each being varied to avoid any appearance of monotony. Many other examples of different types of sketches might be given, but individual effort on the lines suggested will be more useful than the studying of numerous examples of other people's work, so, to gain proficiency in sketching, careful practice is of the utmost necessity, as only by this means can an individual style be developed.

DRAWING FROM THE CAST

GENERAL INSTRUCTION AND EXAMPLES OF WORK

INTRODUCTION

1. Definition.—The term **drawing from the cast** is applied to the rendering, in pencil, crayon, or charcoal, of drawings of solid objects which have been cast in plaster. It is possible by means of perspective drawing to represent thickness without shades or shadows, and this is accomplished by two methods: first, by causing the lines of the object to converge toward a given point, called the vanishing point; second, by representing different details of the object smaller in scale in proportion to the distance they are from the eye. The former method exists in the rendering of architectural objects and geometrical forms that are bounded by straight lines, and the latter prevails in landscape drawing, where a distant effect is given to trees, houses, and other accessories by rendering them proportionately smaller as they recede from the eye.

2. Outline.—Where drawings are rendered in light and shade, an effect of distance is expressed by decreasing the shade values as the object recedes from the eye, as will be explained hereafter. As a matter of fact, there is no such thing as an *outline* bounding an object in nature. The appearance of outline is due to the fact that different surfaces possess different shade values. This is illustrated in Fig. 1, where a cube is shown, one side of which *a* is illuminated by the full strength of light; the second side *b* is in partial shade, while the third side *c* is in deeper shade. Where

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these shade values meet, an apparent outline is established, but the outline exists only on account of the different shade values.

3. Value.—The term **value** is applied to indicate the degree of light or shade, or the relation of shade tones to each other, and is dependent on the quantity of light they reflect, regardless of their colour, and consequently many different colours may possess the same shade value. However, there is usually quite a decided difference in value between different colours, so that it is possible to render a drawing in simple light and shade, and at the same time express to a certain extent colour values.

There is this difference, however, in the system of rendering: In light-and-shade drawing, black is usually taken as the standard or unit of comparison; the strongest values are those that approach most nearly to black, and the lightest or lowest values are those that approach most nearly to white. In colour work, however, the unit for comparison is white, and the strongest values are those that reflect the most light to the eye and approach most nearly to white, while the lowest values are those that reflect the least light or approach most nearly to black. It must be borne in mind, however, that in referring in this manner to black and white, these terms or colours are used in a general way only, and it is safe to assume, for practical purposes, that white exists only where an object is in full sunshine, and black exists only in absolute darkness.

4. Colour and value are dependent on reflected light, and where no light exists all colours appear black. This can be understood if it is assumed that a sheet of white paper is placed in an absolutely dark room; the paper cannot be seen, therefore its value is black. On the other hand, a black cube placed in full sunlight would show in a photographic reproduction with but one of its sides approaching black, and that the one farthest from the sun.

In drawing an object, it should therefore be borne in mind that its colour value must never be confused with its light-and-shade value, for, as just shown, a dark-coloured object may possess the lightest shade value.

5. High Light.—The brightest spot or lowest shade value is usually called the **high light**, and its form and strength vary with the character of the illumination and the surface of the object on which it is found. Thus, in Fig. 1, the high light is on the surface *a* and is moderate in tone, giving the impression of an even, rather dull, and smooth surface. In Fig. 2, however, the high lights are in strong contrast with the rest of the surface owing to the smoothness of the material of which the object is composed. The high light in this case consists of a distorted representation of the source of light itself.

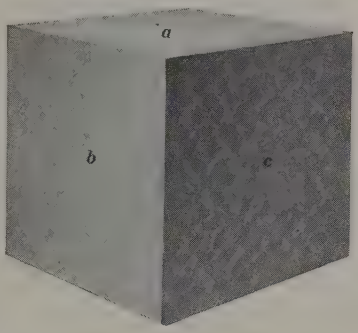

FIG. 1

FIG. 2

6. If a bottle or decanter is placed on a table and viewed from different points, it will be observed that there is always a brilliant spot on it representing the high light that is in reality a reflection of the window opening, the gas jet, or the sun itself, and characterizes the surface as being a smooth and shiny one. Where the surface is highly polished this high light will always be a distorted reflection of the window or other source from which the light comes. A partially or half-polished surface will possess a marked high light

also, but owing to its lack of brilliancy and its absence of form, this high light will convey the idea that the object has a dull, although not absolutely flat, surface, as shown in Fig. 3.

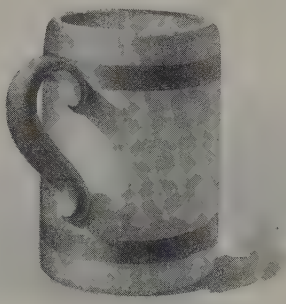

Fig. 3

7. Textures. — A comparison of Figs. 1 to 3 will illustrate that the character of lighting of an object determines its surface or material. This characterization or expression of the particular quality that characterizes any material represented is termed **texture.** Thus, in Fig. 1 is shown a cube that may be of any solid, opaque material, with rather a dull, unreflective surface. The texture could be emphasized, if of wood, by indicating the grain, if circumstances demanded it. In Fig. 2, however, the shape of the object, the transparency of some of its parts, and the reflected high light, indicate conclusively that it is glass. In the mug, Fig. 3, is seen a dull, opaque surface, with a feebly reflected high light, and it is immediately associated with that partially glazed earthenware so characteristic of this class of utensil.

8. In drawing from the cast, as a rule, but one texture is dealt with: that of dull-surfaced plaster. Marble models would usually possess a higher reflective surface and require a more subtle rendering, as the high light would form an important detail of representation. But it must be borne in mind that these cold plaster surfaces must be as characteristically rendered as though each were of a different material, in order to become familiarized with the planes or surfaces that reflect varying degrees of light and give texture to the subject.

9. Necessity for Observation.—It is most difficult for the art student to learn to see. It is safe to say that fully one-half of the people in the world go through life and see less than

one-quarter of the beautiful things about them. Few people, who have not been trained to see the objects about them in a proper manner, can give an accurate description of the shape of an oak leaf, or a maple leaf, or an ivy leaf, yet many may be able to recognize one of these the moment they see it. A general impression has been made on the mind without any attempt to actually see the object as it is; whereas, one moment's careful attention to the subject will impress it on the mind permanently.

It is the same with other objects. On seeing a cube such as in Fig. 1, few persons could sit down and draw it so that it would look anything like the original, without having carefully studied its light-and-shade values. The art student, then, must see these values. He must look at an object as being composed of a number of planes or surfaces, each one possessing a certain value, and realize that the effect of an arrangement of these values determines the form, proportion, and appearance of the object. This is difficult at first, as the eye will focus itself on a certain portion of the object and see only that portion, while the other portion remains obscured or blurred. As soon as the mind takes into consideration the shade or shape of some other portion, the eye will wander to that portion and focus clearly on it. These movements and changes of the eye and mind follow one another in such rapid succession that an impression is created of having seen the entire object in detail at one glance, whereas, as a matter of fact, many glances have been necessary.

10. This appearance of detail must be avoided to a certain extent in rendering the work, as the finished drawing is likely to look more like a microscopic representation than an art study. The aim of the artist should be, not to draw every detail with the most minute accuracy, but to give strength of character to the whole rendering, by broad masses of shadow representative of each part, as though the eye were focused on but one part and received the impression of light and shade from the other, precisely as it does in nature.

11. It is of the utmost importance that the masses of shadow and high light should be considered first, and the detail worked

out afterwards. The object should be blocked out as a whole and each section worked up to the desired degree of finish afterwards. The general form and mass of an object, as well as its relative light-and-shade values, can be determined to a certain extent by partially closing the eyes and observing, by means of the dim light that is permitted to penetrate between the lids, the object that is being drawn. In this way the object will divide itself into two masses of light and shade without intermediate values, and the rendering of these two masses should form the first block form of the object.

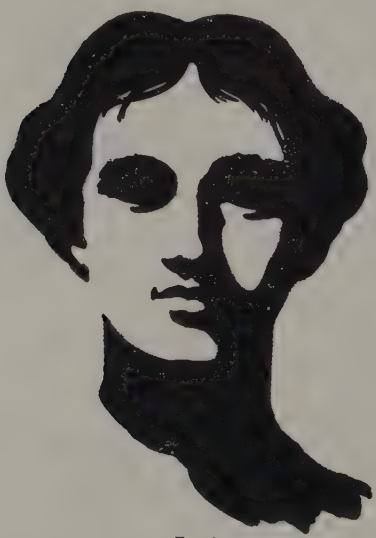

Fig. 4

12. In some instances this massing will be all that is required, while in others certain details must be worked up more fully. For example, Fig. 4 is a rendering of a plaster cast in which nothing has been detailed or outlined, but the shadows simply executed in solid black. The mind is subtle and readily grasps the idea of what is intended and completes the appearance that is required. Practise rendering the objects in two values before attempting to even up the surface and blend one value into another. *The artist sees effects, not objects.*

13. Half Tone.—So far, light and shade have been dealt with simply as two elements in rendering, and while it is possible to consider a great multitude of values between absolute black and perfect white, the rendering of these values may be reduced to a very few simple tones. The first of these tones to be considered is midway between black and white, and may be termed **half tone,** although in general criticism of drawings, a half tone is

any tone midway between the darkest and the lightest tone of the subject. In Fig. 1, the surface *b* is a half tone, as it is half way between *a* and *c*.

Where an object is rendered in three tones, as is oftentimes the case, the half tone is practically its true colour, whether the object is rendered in colour or simply in light and shade. A light-and-shade value of the colour of the object is rendered in half tone, as the high light is reduced in value owing to its brilliant illumination and the shadow is increased in value owing to its lack of illumination. Therefore, as in Fig. 1, if it is desired to represent a cube or other solid whose colour is a grey, that colour is indicated on the side *b*, and the depth of that colour determines the depth of the deepest shade *c*. If the cube is a very light grey, then that tint can be indicated at *b*, and the deepest shade would be but a few shades darker on *c*. If the cube should be a very dark grey, the depth of tone would be indicated on *b*, and the deepest shade at *c* would probably approximate nearly to black.

14. Reflected Light.—That light which is often seen on the shaded portion of an object, owing to the fact that surrounding objects reflect their light on it, is called *reflected light*. In rendering a drawing, reflected light is considered far less important than the direct light, and must never tend to confusion or exaggeration in the conditions represented. It must always be considered much lower in tone than the direct light, and may in many cases be omitted entirely, particularly in light-and-shade rendering.

Reflected light is of more importance in colour work, as, for instance, in the case of a blue polished vase standing on a yellow table cover. The high light in the blue vase will appear to the eye as white, whereas the high light from the reflected table cloth will appear to the eye as green, owing to the commingling of the colours of the vase and the table cloth. This representation of reflected light in colour is necessary in order to give an appearance of reality to a drawing, but is of much less importance in light-and-shade rendering, as colour forms so small a part of the consideration.

15. Shadow.—Shadow is a term applied to the absence of, or the result of interference with, light through the interception of some opaque object. In Fig. 5 is shown a pyramid illuminated on the right side; its back *a* is in shade, and it casts a shadow *b* on the ground, inasmuch as the light is intercepted owing to the opacity of the pyramid. The part of the shadow nearest the side of the object that casts it, is usually darker than the shaded

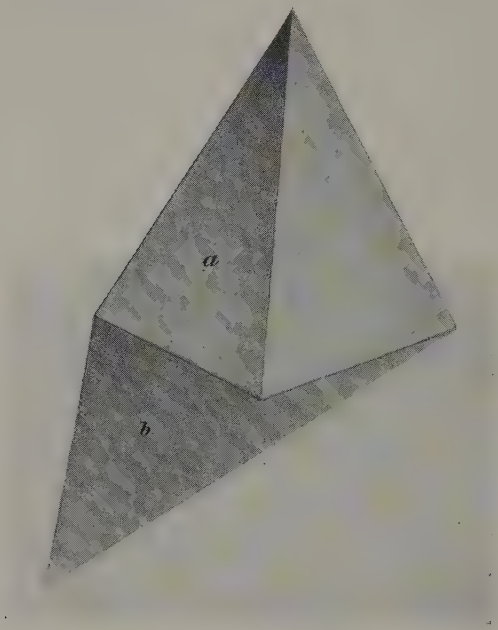

FIG. 5

side of the object; that is, the part of the shadow *b* next to the pyramid is darker than the side of the pyramid *a*.

Shadow differs from shade, inasmuch as it has a definite shape or form dependent on and somewhat resembling the form of the object that casts it. Thus, the shadow *b* of the pyramid has the form of a pyramid, and the shadow of a man in full sunlight would have somewhat the form of a man. *Shade*, however, is

indefinite and simply extends over a surface in an arbitrary way on the side of that surface turned from the light.

16. Rendering.—In rendering a drawing, the only way to secure the true light, shade, and half-tone values is to reserve the surface of the paper on which the drawing is rendered to represent the high lights, and then render the rest of the object in an even tint for the half tone. Over the half tone the deepest shadow may be worked, and the result is the rendering of the object in three tones. The finishing of the drawing, including the transition from deepest shade into half tone and half tone into high light, is accomplished by the softening of the edges on curved surfaces where one shade runs into another.

It is evident from the preceding statement that before attempting to make a shaded drawing, the art student must be familiar with outline drawing. He must not only be able to outline his object clearly, but must also be able to outline the high lights and the half tones on that object. This being done, the blending of one into the other is all that is necessary to produce that soft effect so characteristic of crayon and pencil drawing.

17. While preliminary outlining of the high lights and shades is necessary, it must not be forgotten that there is no such thing as outline in nature, and in the finished drawing this outline between high lights and shadows must be destroyed by blending one into the other through subtle transitions that cannot be detected by the eye. The only exception to this principle is in rendering some shiny object, as in Fig. 2, where the high light is sharply profiled against the half tone, thereby indicating the texture of the polished material that reflects it.

The outline is used only as a guide to the hand and is necessary as a framework round which to build the shades in the same manner that a framework is necessary for a house in order to support the detail. Ruskin, the great art critic, says: "A good artist habitually sees masses, not edges, and if one can put on paper patches of colour or shade of exactly the same size, shape, and gradation as those on the object he is representing, he will produce an exact portraiture of the object itself." The principal necessity for an outline is to prevent one from losing his way and

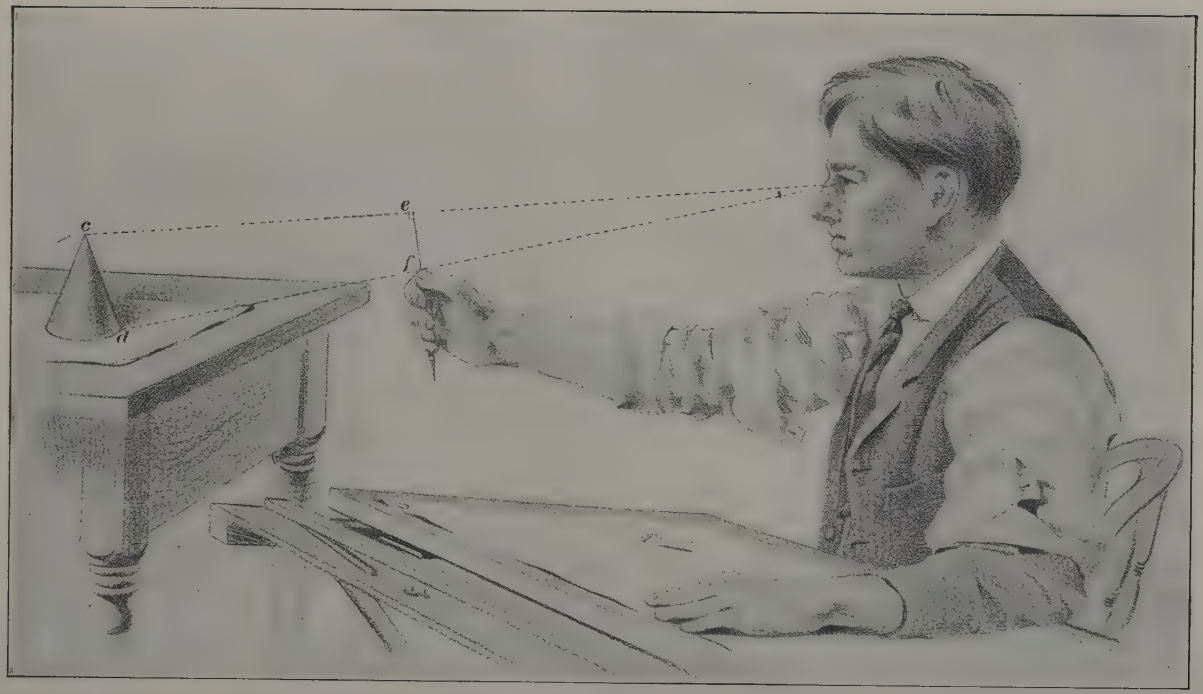

Fig. 6

overdoing detail as he applies the shadows. The outline is a guide to the eye and hand. Again, in this connection Ruskin says: "The power of shading depends upon the lightness of the hand and the keenness of the sight."

MEASUREMENT AND PROPORTION

18. In making a drawing of any object it is necessary to use some system of measurement by which various parts of the object can be properly proportioned, one to another. A simple solid, such as a sphere or a cube, should be easily drawn without material reference to any system of proportion, inasmuch as the eye is sufficiently familiar with such forms to proportion them correctly without other aid. But with complicated figures, such as parts of the human body, it is necessary to have a system by which they can be proportioned so that the eye can become trained to realize what relative size one part should be in comparison with another. The simplest method of calculating these proportions is by means of pencil measurement.

19. Drawing of a Cone.—In Fig. 6 is shown a cone, the height of which *c d* can be determined by holding the pencil at arm's length, as shown, and closing one eye. The pencil is then held so that its end *e* will coincide with an imaginary line drawn from the eye to the point *c* of the cone, and the thumb is moved until it marks the base of the cone at *d* at the same time and in a similar manner. The distance *e f* on the pencil then gives a standard of measurement for the height of the cone *c d*, and can be transferred to the drawing paper, and set down as a line shown at *a b*, Fig. 7 (*a*). The width of the cone can then be measured by holding the pencil horizontally, as shown in Fig. 8, keeping the end of the pencil in a line with the side of the cone *a* and marking the width of it with the thumb at *b*. The distance *g h* thus marked off on the pencil in Fig. 8 will then be a measurement of the width of the cone, and a line *c d*, Fig. 7 (*a*), can be drawn by the side of the line *a b* as the standard of width.

These lines form standards of measurement from which a cone of any size may be constructed in proper proportion to the

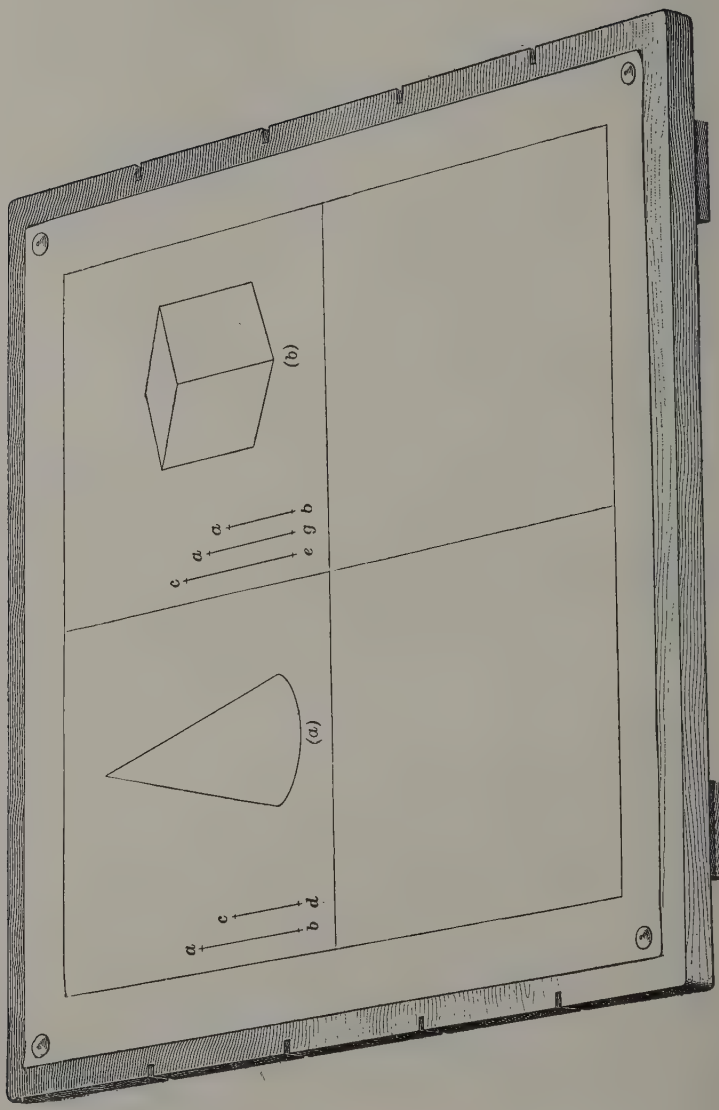

Fig. 7

FIG. 8

original. In making these measurements it is necessary that one sit as nearly as possible in the same position when taking each measurement, and that the arm be extended to its full length in order that the distance from the eye to the pencil may be uniform ; otherwise, inaccurate proportions will be given and a poorly proportioned drawing will be the result. The pencil should also be held at right angles to the line of sight, not slanting either perpendicularly or horizontally, as an inclination of the pencil toward the object would invariably render the proportion longer than it should be.

20. The relative proportion of the two lines, as shown in Fig. 7, will give the relative proportions on which to draw the cone. In this case it will be observed that the width *c d* is two-thirds of the height *a b*, and a drawing of any proportions can be set out wherein the width of the cone at its base is made two-thirds of its height. This process, it will be seen, is a very simple one when there are but two measurements; but it may be just as readily accomplished where there are more measurements, provided sufficient care is taken in gauging them exactly and setting them off proportionately to one another.

21. Drawing of a Cube.—In drawing the cube in Fig. 9, measure the height *a g* from the lowest portion to the highest portion, as before described, setting off this height as shown at *a g*, Fig. 7 (*b*). Then measure the width from *c* to *e* and set this off at *c e*, Fig. 7 (*b*), and as the line *a b* is directly in front of the eye, this measurement can be set off at *a b*, Fig. 7 (*b*). There are now three general proportions on which to construct the cube.

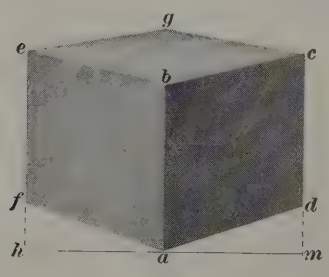

FIG. 9

The width of the cube being greater than the height, it is best to take this as a standard of proportion, and it is found by comparison that the height is four-fifths of the greatest width, and that the height of the nearest line *a b* is three-fifths of the

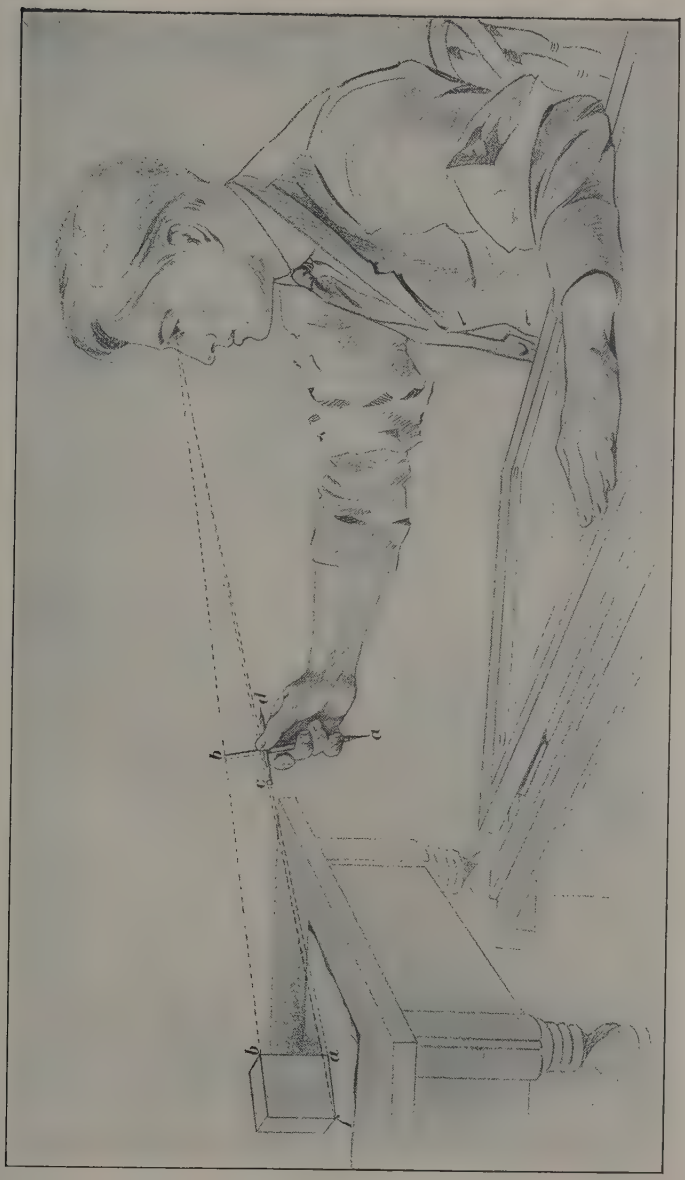

Fig. 10

greatest width. The proportions for the height in front are 3; for the greatest height 4, that is, from *a* to *g*; and 5 for the greatest width, from *d* to *f* or from *c* to *e*. If it is assumed that the width to be set off is 5 inches, a base line *h m* may be set out, 5 inches in length; and at its centre the line *a b* may be set off, 3 inches, while the point *g* should be situated 4 inches over *a*. The sides *e f* and *c d* should then be judged by the pencil and set out in proper proportion, and the whole figure completed by connecting up the points so found.

22. The angles formed at *a*, *b*, and *f* may be judged approximately by the eye in most cases, but where it is necessary to get them exact, they may be carefully measured by means of two pencils held in the hand, as shown in Fig. 10, and so separated that each pencil corresponds with one of the lines meeting to form the angle; that is, the pencil *a b*, Fig. 10, can be held at arm's length so that it is parallel with the line *a b*, Fig. 9, and the pencil *c d*, Fig. 10, at the same time maintained parallel to the line *a f*, Fig. 9. In this way the angles may be set off exactly, and a perfect outline drawing of the cube as it appears to the eye from a given position can thus be rendered. If the position of the cube is changed so that its angle is not directly in front of the eye but to the right of it, as shown in Fig. 11, the same method may be used. The entire height from the base line *h m* to the highest corner *g* may be measured; also, the height of line *a b*, and the width from *c* to *e* set out, while the angles, measured as before described, may be plotted in their proper places.

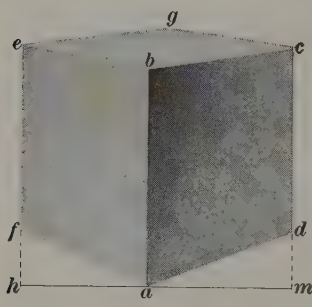

FIG. 11

23. Practise frequently these simple forms until capable of taking the measurements with exactness. In drawing the figures from the measurements, vary the proportions, making them smaller and larger than the dimensions thus measured, in order

to train the eye and hand to work together; or, in other words, set off the measurements as shown in Fig. 7, and vary them, making a cone twice the size of these measurements, another one-half the size, and another one of some other proportion, bearing in mind that the width is two-thirds the height or whatever else may be found by the pencil measurement in actual practice.

MAKING THE DRAWING

24. Introduction.—In drawing from plaster casts, bear in mind that there is something more to accomplish than the mere representation on paper of the object. The drawing of these simple forms is absolutely necessary in order to train the eye and hand to work together and at the same time accustom the eye to the natural proportions of one part to another. It thus forms a stepping stone toward drawing from life or drawing from nature, but it has this advantage: the cast is always motionless, while the human figure posed for drawing is subject to changes of position as fatigue sets in, and lack of familiarity with the proportions of the parts is likely to render the drawing of one portion of the body as it appeared at the commencement of the pose and other portions as they appeared after the figure had sagged from weariness.

Constant drawing from the cast is therefore necessary in order to become familiar with the relative appearances of the different parts of the figure, and to judge, when working from the human figure, whether each detail is rendered in its proper relation to the several other details. It is not within the province of this Section to explain how this result may be best effected in life drawing; this Section will be devoted to the proper eye measurement and rendering of various portions of the cast, in order that it may be properly depicted on paper or canvas.

25. Drawings from the cast are generally finished in monochrome, or simple light and shade of a single colour, and the models, when details or parts of the human body, are relieved of all surface peculiarities, such as the texture of the skin, wrinkles, and other characteristics of individual cases. The whole broad

outline is shown with a smoothness that is standard in all cases ; and it may be varied when the time comes to make it characteristic of the individual. The same cast may be hung in different positions, giving different effects of light and shade, foreshortening, etc., that will be of great advantage when the more important work of life study is commenced.

26. Subdivision of Subject.—Drawing from the cast of the human figure may be divided into three parts : the drawing of the whole figure, the drawing of different parts of the figure, and the drawing of the head. These should be studied alternately, in order that their relative importance may be appreciated. The whole figure must be studied for its action, the axial directions of its main lines, its proportion, its construction, etc. The fragment or individual member should be studied in order to become familiar with details on a large scale, and to emphasize the study of construction, and also to learn the effects of foreshortening, the direction of various planes, and the character of the subtle contours. The head should be specifically studied to get its general structure, strong facial lines and features, and characteristics of execution that in various individuals give expression and individuality.

Considerable attention should be given to the freehand drawing of straight lines, so that vertical, horizontal, and oblique lines may be drawn with a fair degree of accuracy and truth of direction ; also, so that the eye may be able to judge the characteristics of certain curves and represent these curves approximately correct on the paper. Outside of the actual drawing of models and casts, too much attention cannot be given to these simple details.

27. Correction of Errors.—If a drawing does not appear satisfactory when completed, careful study should be given to the object from which it is drawn, in order to discern, if possible, wherein the error lies. All angles should be carefully tested by means of two pencils, as described in Art. **22.** The lengths of all lines should be checked by means of pencil measurement, and an endeavour made to even up any irregularities that may appear. It will be frequently found, in thus checking the drawing, that

the pencil measurements do not agree entirely with those that were made first. This will probably be due to the fact that the position has been changed somewhat, and owing to the eye approaching nearer or receding farther from the figure, the measurements will be larger or smaller than those first taken. In such cases, for the purpose of checking, it is best to change the position until the length of line as first set down as a standard of measurement will agree exactly with the checking measurement for the same dimension. Then, any variation that is found with the other measurements can be corrected with some degree of satisfaction.

28. Arrangement of Light.—In drawing from any object, the arrangement of the light is of vast importance. Where it is possible, a north window gives the best light, as the sun's rays seldom enter it, and an even diffusion or spreading of the illumination is thus effected, causing soft shadows and lack of harshness. Where a north light is not available, the model should be placed away from the direct rays of the sun and the window blinds in the room so drawn that the sun's rays are excluded. In any case, the cast should be placed so that the light falls on it from the draughtsman's left and somewhat above his head. In an ordinary room this may be accomplished by hanging the cast near a window, and blocking up the lower portion of the window so that the illumination comes from above only. Any other light that would tend to illuminate the right-hand side of the cast should be extinguished or cut off in order to prevent confusion in the shadows. It is most essential that the line where the shade ends and the high light begins should be seen correctly, and this can be studied satisfactorily only when the light falls from one direction.

29. Materials Used.—For practice in drawing from the cast, use charcoal paper fastened to a drawing-board with two or more drawing-pins. The board may be placed on an easel, or it may be held in the lap and allowed to rest against the back of a chair or a table. Soft india-rubber may be used to remove pencil marks if the object is drawn in lead pencil, but a piece of stale bread is far preferable where the drawing is rendered in soft

crayon or charcoal. After the drawing is entirely finished, it is necessary to spray over it a thin varnish or preparation of gum arabic, usually called *fixatif*, in order to prevent the crayon or charcoal from rubbing or smudging and thereby destroying the neatness of effect. The fixatif is spread on the drawings by means of a *sprayer*, one end of which is inserted in the fixatif bottle and the other held between the lips. By blowing through it, at a distance of about 18 inches to 2 feet from the drawing, an even spray of the varnish is spread entirely over the surface. Very little fixatif is required for this purpose, an excess giving a sticky and glossy effect to the paper, and great care must be taken that a good fixatif is selected, as the cheaper kinds are very liable to stain the paper and spoil an otherwise good drawing.

30. Size of Drawings.—For practice work, make the drawings as large as possible, as when the eye is once trained to do work on a large scale, it is a simple matter to execute the same from memory on a small scale. Artists and illustrators, in studying from the human figure, invariably make their studies as large and as broad as possible; but when they sketch compositions, in order to arrange the various details before the picture or illustration is started, they sketch their figures from memory on a very small scale and arrange them relatively to one another, about as they would like to have them appear in the finished drawing. Knowledge sufficient to carry out the broad details renders the making of composition sketches a comparatively simple matter, and it is safe to feel that drawing on a large scale is conducive to freedom and accuracy.

31. Having practised the drawing of simple forms, taking the proportions thereof by means of the pencil extended at arm's length, now devote some time to the shading of surfaces before attempting to render parts of the human figure in a drawing. Shading on drawings is rendered in pencil and crayon work by means of a series of parallel lines, evenly spaced at first, but afterwards blended together.

For practice, draw a square about 2 inches on each side, and then render the surface of same, by means of parallel lines, in even monotone, as shown in Fig. 12 (*a*). Being able to secure

a uniform shade in this manner, attempt spacing the lines more closely so as to produce an even tint without apparent lines, except those formed by the *tooth* of the paper, as shown in Fig. 12 (*b*). By using more pressure and a greater number of lines on one side, the tint can be graded until an effect similar to that shown in Fig. 12 (*c*) is obtained. In doing this, the whole square is shaded over in the lightest tone first, and then the darkest tone is applied in the lower left-hand corner. The dark tone is then extended, gradually lessening the pressure with which it is executed, until it blends softly into the lighter tone without any line of demarcation. Generally speaking, only three degrees of shading are made use of in the first drawing: the deepest shade, half tone, and white. These are then blended one into the other, where necessary, in order to produce intermediate gradations

(*a*)

(*b*)

(*c*)

Fig. 12

32. Oftentimes shadows stand out very prominently and in sharp contrast with a very light surface; at other times they will blend into a dark shade so that their edges can be hardly discerned. Owing to the influences of reflected light, shadows sometimes start in a very dark tone and gradually become paler until they softly blend into the lightest tone of the drawing. The necessity for the portrayal of any of these conditions will constantly occur in actual work, and therefore such practice in the blending of dark into light, as shown in Fig. 12 (*c*), is of the greatest importance.

DRAWING PLATE, TITLE: GEOMETRICAL SOLIDS

33. Execute on this drawing plate four figures, drawing the border line 17 inches by 13 inches, on a sheet of paper 18 inches

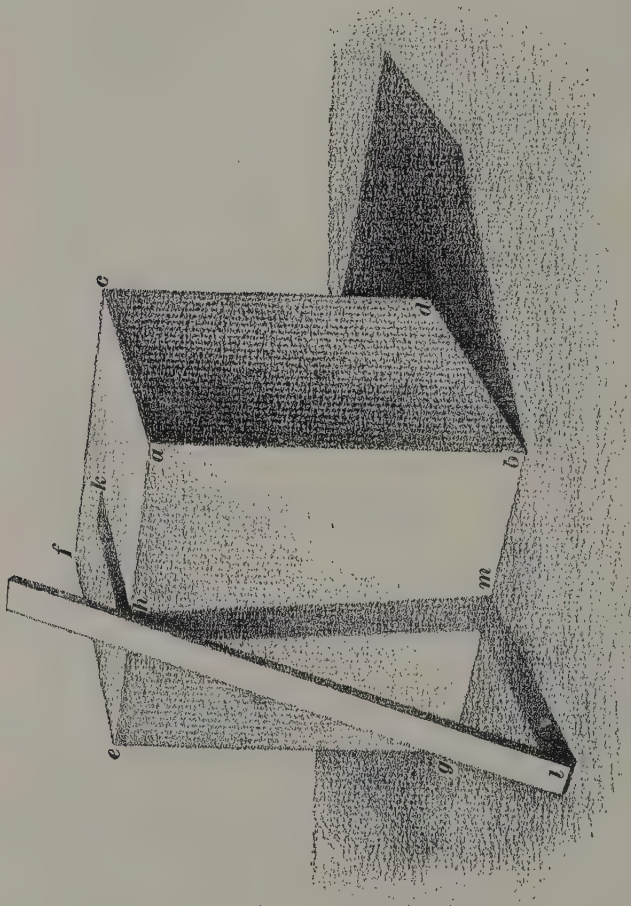

FIG. 13

by 14 inches; 6 inches above the lower border draw a horizontal

line across the plate and then a vertical line through the centre, dividing the plate into four rectangles. Each of these rectangles will contain one of the four examples of solids that constitute the drawings on this plate. The first figure on the drawing plate will be a reproduction of Fig. 13 and should be executed in the top left-hand rectangle. This figure need not be copied exactly ; it would be better to take a cube or square box of some kind, stand it on a table 6 or 8 feet distant with a straightedge or similar rod resting against it as shown, and render the cube with its shadow just as the light falls on it and in accordance with the following directions as to shading.

In this case, make the side of the cube nearest the eye about 3 inches in height, and the total width from *e* to *c* about 4 inches. Therefore, the height will be three-fourths the greatest width. The rectangular rod leaning against the cube is in reality about 5 or 6 inches in length, although it appears much smaller owing to its position in the drawing. The lines *a c* and *b d* at the top and bottom of the cube converge toward a vanishing point as they recede from the eye, and the line *e f* converges toward *a c* as it vanishes toward the same point. The lines *c f*, *a e*, and *b g* converge and vanish to another point toward the left. The straight rod leaning against the cube strikes its upper edge at about one-third of the length *e a* from *e*, and the shadows cast by it from *h* to *k* and *l* to *m* vanish toward the same point as the lines *a c*, *b d*, etc. The shadow against the side of the cube *h m*, is not parallel with the side *a b*, but inclines slightly toward *b*, as the source of light is evidently to the left of the rod.

34. Having drawn the cube lightly in outline, proceed to complete the drawing as shown. It will be seen that the faces *a b g e*, *a e f c* of the cube are in high light, so that they can be left almost entirely as white paper. If, however, they were left to remain as white paper, the finished drawing would not look well or true to the original. A certain amount of shading is therefore put on, commencing at the corner *e* on the face *a b g e*, as shown, and is gradually graded off until it merges into the white paper, and this is left alone as at the corner *b*. The rendering of this tone will require a very light touch of the crayon, and

must be done very slowly and carefully in order to secure a uniform tint. In a similar way the face *a e f c* is treated. This amount of shading gives a feeling of texture to the two faces, and prevents them from looking insipid. The face *l* of the rod is left entirely as white paper, as this face is probably directly at right angles to the source of light.

35. The dark side *a c d b* may then be rendered in the darkest tone intended to be used on the drawing. It should not be perfectly black, however, as this gives a heavy, opaque appearance to the object and destroys the transparency of its shadow. The tone on this side, it will be observed, is lighter toward the bottom than at the top, and it will be necessary to render the whole side in the lighter tone first and then gradually darken it in order to produce the desired effect. The shadow may then be drawn in as shown, observing that next to the cube, as cast on the table, it is considerably darker than toward the edges. The shadow of the rod, being against the cube, is about the same tone as the shadow of the cube itself where this shadow starts from the points of contact, that is, at *l* and *h*, but the shadow of the rod lightens somewhat as it extends toward *m* and *k*.

Having completed this drawing and indicated the background lightly, as shown, protect the other three rectangles on the drawing plate that are subsequently to contain drawings, and then spray the finished drawing with fixatif before attempting to execute the others. In this way will be avoided much trouble caused through the hands coming in contact with the unfixed drawing, thereby smudging it and rendering it necessary, possibly, to be redrawn.

36. Six-Sided Prism.—In the next rectangle to the right of the one containing the cube, render a drawing of a six-sided prism standing on end, as shown in Fig. 14. In this prism, the side *a b* is about 5 inches long, and the lines *a d* and *b c*, though parallel in reality, vanish toward some point to the right. Each other pair of parallel lines in the original also vanish toward some point, and although this point may be very remote, it is important to bear in mind and see that the lines converge slightly in order to prevent a distorted appearance in the rendering.

The side *a b f e* possesses the lightest tone and should be rendered similar to the side *a b g e* in the previous figure. The dark side *d g h c* should then be rendered in the darkest tone, being careful to grade the tone from top to bottom as before. The

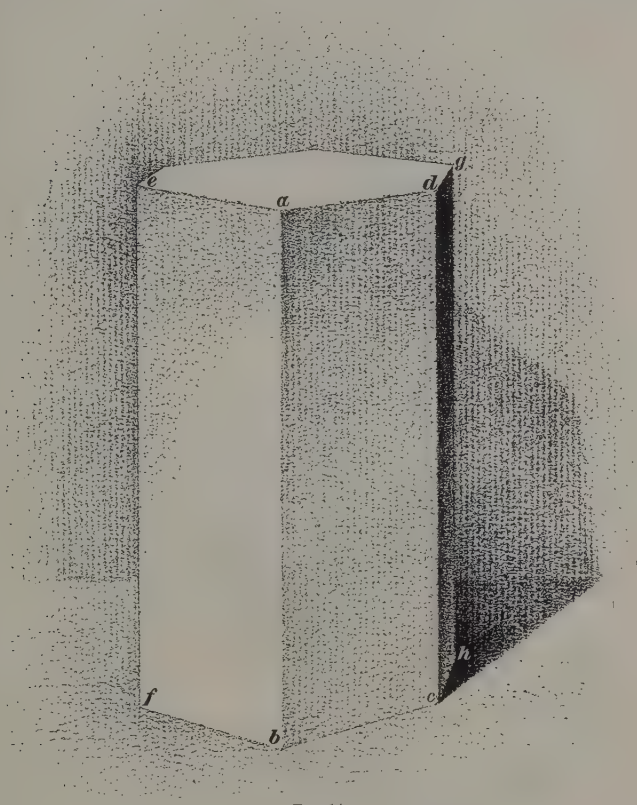

Fig. 14

shadow of the prism in this instance extends across the table to the wall and upwards on the wall. Observe that the line of demarcation between the face *d g h c* of the prism and the shadow is not all distinct, the shadow on the wall being nearly the same tone as the shade on the side of the prism. The lower part of

the prism, all round, is a trifle lighter in shade than the upper part, owing to the reflected light from the table, while the table itself possesses a tone equal to the upper part of the side *a b f e*.

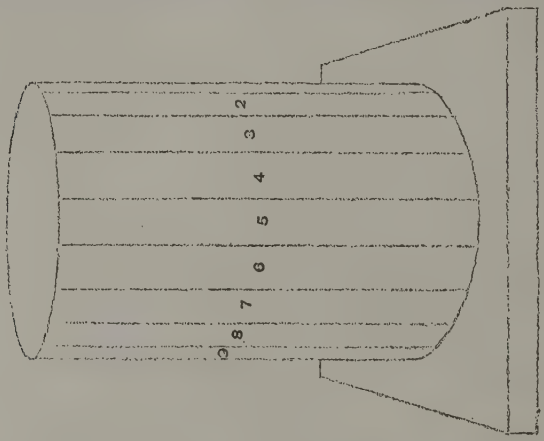

FIG. 16

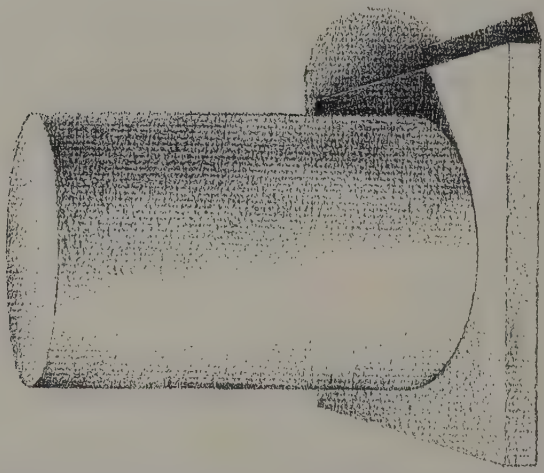

FIG. 15

The highest light on the prism is on the hexagon forming its top, and this should be left white, or tinted only a shade darker than the drawing-paper itself.

37. Cylinder Standing on a Block. — Having finished and sprayed this drawing with fixatif, proceed to the drawing of the cylinder shown in Fig. 15. This should be placed in the lower

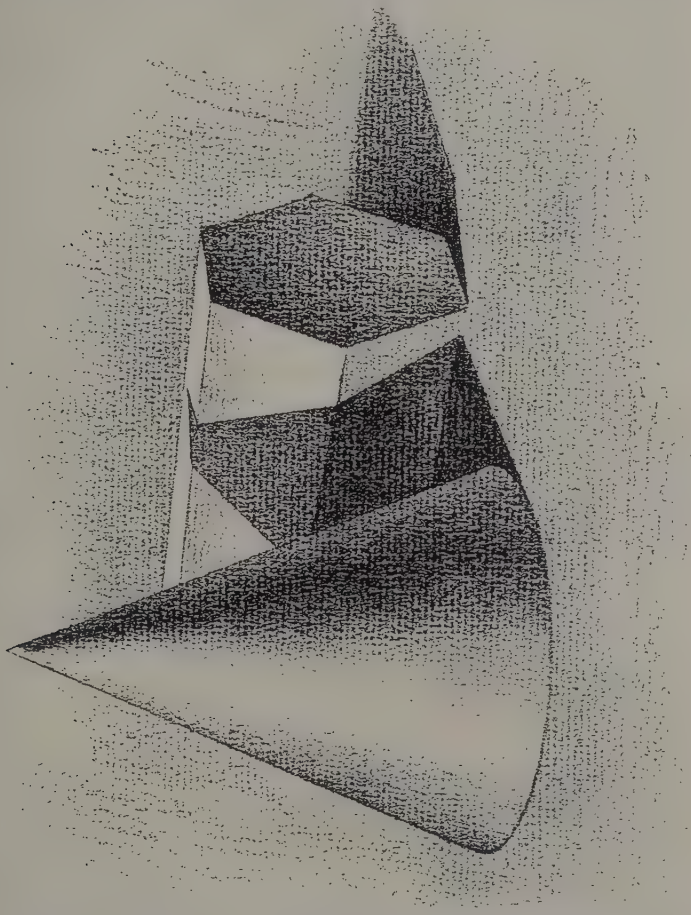

Fig. 17

left-hand rectangle of the drawing plate. This cylinder is about 5 inches in height, the ellipse forming its upper side being about 3 inches along its greater axis. The cylinder stands on a block

about 5 inches square and $\frac{3}{8}$ inch thick, the sides of the block vanishing quite perceptibly as they recede from the eye. The lightest tones on this drawing exist on the table, on the block to the right of the cylinder and toward the left-hand side and on top of the cylinder itself.

38. In rendering the shade values on this cylindrical surface, first consider it, similar to the hexagon, as a figure with a number of plain surfaces or sides. The figure should first be divided into a number of vertical strips, as shown in Fig. 16. If the surface is thus divided into nine strips, as shown, and *3* is considered the darkest, then the darkest tone should be on *3*, and *9* should be shaded to correspond with the tone of the top of the cylinder. The strip *7* will then be the high light, and the other tones will be intermediate between *7* and *3*. When these tones have been established, the harsh line defining them should be gradually blended off from each dark tone into the next lighter one, until an even curved surface similar to that shown in Fig. 15 is presented.

39. The shadow cast by the cylinder and by the block on which it stands is considerably darker than the darkest shade on the cylinder, but the front edge of the block that is shown in shade is equal in value to about strip *5* of the cylinder. Observe, in rendering this, as in other cases, that the shade on the cylinder becomes perceptibly lighter toward the bottom, where it contrasts with the dark shadow. After completing this drawing satisfactorily, spray it carefully, to preserve it, and proceed with the last figure on the plate, shown in Fig. 17.

40. Cone and Prism.—The base of this cone is about $3\frac{1}{4}$ inches in diameter and the height on its axis is about 4 or $4\frac{1}{2}$ inches from *a* to *b* as shown in Fig. 18. A hexagonal prism similar to that shown in Fig. 14 stands behind the cone and receives part of the shadow cast by it. The base of this cone should be divided in a similar manner to the top of the cylinder in Fig. 16, and lines drawn from these divisions to the apex *b*. Each of the small triangles so formed should then be shaded as in the case of the strips shown in Fig. 16, the darkest being at *3* and the lightest at *7*.

Take particular notice how the shade grades from the apex of the cone toward the base, so that in the finished drawing, Fig. 17, sections *1*, *2*, and *3* of the base are nearly of the same tone,

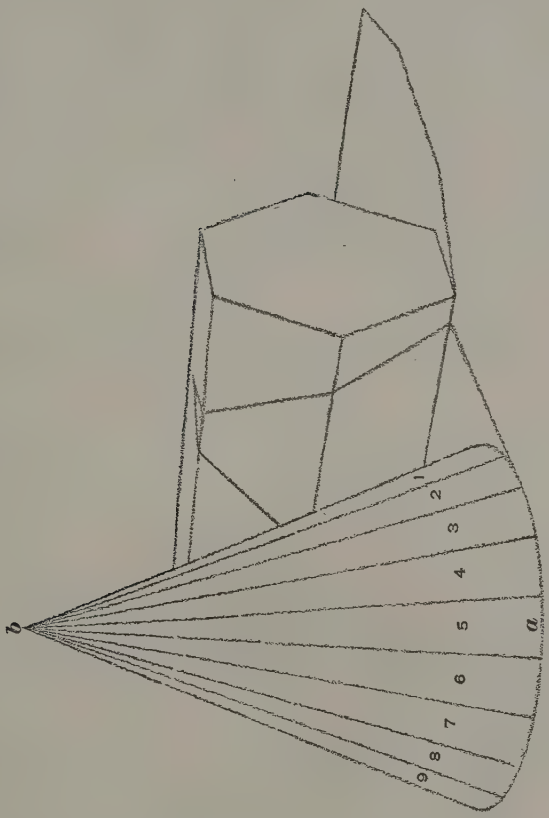

Fig. 18

while at the top the tone grades off rapidly to the left and is much darker in section *1* than at the bottom. The contrast of the light side of the prism against the darkest part of the cone is very effective in this case, and should be carefully studied.

41. The shadow cast by the cone is about as dark as the darkest part of the cone, but the shadow cast by the end of the prism, being more distant, is not rendered in as dark a tone as the shadow cast by the cone, as this method of rendering gives the effect of perspective. The shadow cast by the prism and the darkest part of the end of the prism are of about the same tone, but the shade on the end of the prism is graded toward the bottom, so that the edge of the prism against the shadow is lighter than the shadow itself, thus establishing its outline. Having completed these figures according to instructions, and *fixed* them satisfactorily with the sprayer, place your name and class letters and number in the lower right-hand corner and the date in the lower left-hand corner of the plate, as usual, and send same to the Schools for criticism.

DRAWING PLATE, TITLE: OUTLINES OF FEATURES

42. This drawing plate will be devoted to the outlining in crayon of three views of the mouth and eye, drawn to a large scale in order to become familiar with the characteristics of these features before attempting to draw them in connection with other parts of the face. The drawing plate, 18 inches by 14 inches, with border line 17 inches by 13 inches, as before described, should be divided through the middle by a line 6 inches above the lower border, and divided horizontally into three equal parts through which vertical lines will be drawn, converting the drawing plate into six rectangles within which each feature will be drawn.

43. Front View of Lips.—In Fig. 19 is shown a full front view of the lips drawn in bold lines to show the characteristics of the mouth in outline. Draw in the upper left-hand rectangle of the drawing plate three vertical lines about $1\frac{1}{2}$ inches apart, as shown in Fig. 19, and with these as guides to fix the centre and corners of the lips, draw, in a few bold lines, the front view of the mouth, as indicated. The upper outline of the upper lip forms a complete bow shape, but particular care must be given

to its upturn at the corners in order to prevent a drooping expression; the short lines marking the ends of this feature, at right angles to the upturned portion, show where the indentations occur in the cheeks. The line between the upper and lower lip dips in the centre, as does the upper line, but not to so great an extent, and the lines connecting this dip with the upturned corners are nearly horizontal. The outline of the lower lip

Fig. 19

should be very lightly indicated, as this is not so prominent as the other lines. Above the centre of the lip are two lines indicating the indentations of the upper lip directly under the nose, and below the lower lip are lines indicating the point of projection of the chin. Do not finish this drawing any more than is shown in Fig. 19.

44. Side View of Lips.—In the rectangle to the right of this on the drawing plate, draw a profile view of the lips, as shown in Fig. 20. A light line inclined slightly toward the left should first be drawn as a guide. The curve from the under side of the nose to the top of the upper lip touches this line, as does also the line of the chin, and it will be observed that the line

stopping the corner of the mouth inclines toward this construction line at the top.

45. Three-Quarter View of Mouth.—In the upper right-hand rectangle of the drawing plate a three-quarter view of the mouth is to be shown, as in Fig. 21. Here three nearly vertical lines are drawn, two of them $1\frac{1}{2}$ inches apart and the other $\frac{1}{2}$ inch to the right. It will be observed that the left-hand half of the lips in this drawing are longer in proportion than those in Fig. 19,

FIG. 20

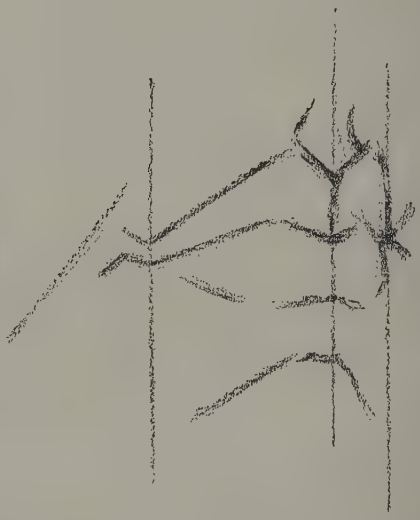

FIG. 21

because, viewed in this position, the visible halves of the lips are seen at their greatest length and are not fore-shortened by the curves of the face as they are in Figs. 19 and 20. The general curves of the lips from the centre to the side line are very much the same as in Fig. 19, although in Fig. 21 they are more extended on the left side and more contracted on the right, the vertical distance between the lines at their several points being practically the same in both cases.

46. Front View of Eye.—In Fig. 22 is shown a full front view of the eye and brow, and this should be drawn in the lower

left-hand rectangle of the drawing plate. Three vertical lines are drawn to act as guides, the two outside ones being 2 inches apart, and the middle one $1\frac{1}{8}$ inches to the right of the left-hand one. These lines mark the extreme visible portion of the eyeball and the centre of the pupil. Observe that the outlines of the upper lid are nearly parallel and straight across the pupil, but droop rapidly toward each side, and that the line of the lower lid is not nearly so curved as that of the upper lid. The two corners of

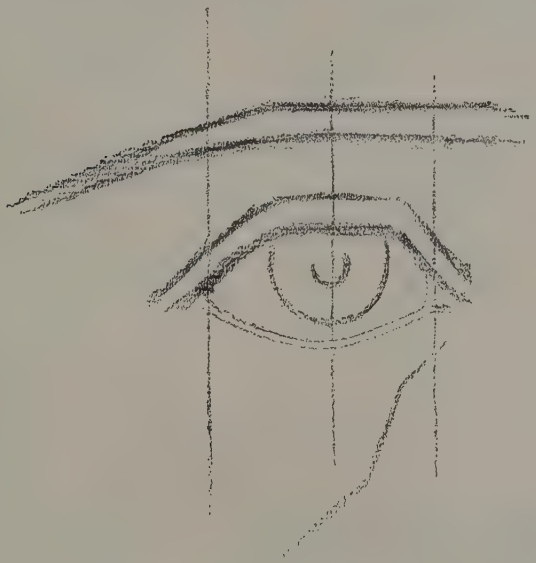

Fig. 22

the eye, however, are practically opposite each other, and the under side of the brow is about the same distance above the under side of the upper lid that the upper lid is above the lower lid. The iris does not extend the full depth of the opening, and the pupil instead of being in the centre of the iris is slightly above.

47. Side View of Eye.—In Fig. 23 is a drawing of a profile of the eye which is to be drawn in the lower central rectangle of

the drawing plate. A guide line should be drawn in at about the same direction as the guide line was drawn in Fig. 20, to get the inclination of the prominent parts of the feature in this position. The line of the lid inclines sharply downwards, almost straight, at an angle somewhat less than 45°. The outer edge of the lid crosses the guide line and the guide line passes through the angle of the eyebrow. The triangle between the pupil and the corner of the eye is somewhat fuller than in Fig. 22, inasmuch as this detail is seen flatter before the eye without foreshortening, as was the case in Fig. 21 with the mouth. Take particular notice of the fulness immediately under the eye, where it extends to the left of the guide line nearly as much as the lid itself, and the lower portion of the eye curving up to meet the upper lid intersects with it at nearly a right angle, although somewhat more acute.

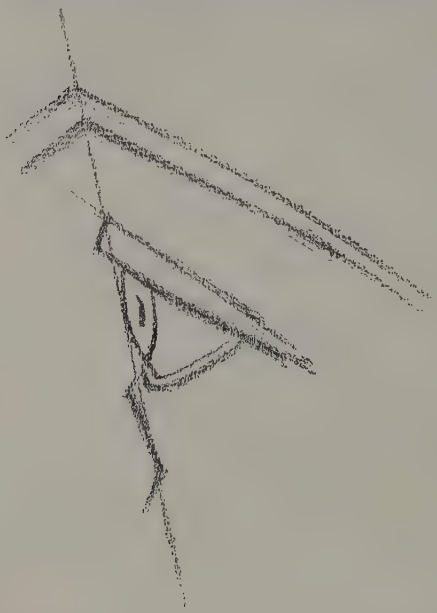

Fig. 23

48. Three-Quarter View of Eye.—In Fig. 24 a three-quarter view of the eye is shown and should be drawn in the lower right-hand rectangle of the drawing plate. The heights remain the same as in Fig. 22, but the lines passing through the corners of the eye are only $1\frac{1}{2}$ inches apart, owing to the foreshortening of the feature in this position, while the line passing through the pupil is 1 inch to the right of the left-hand line. Care should be taken to

see that the different points of prominence in the three views of the eye are on the same horizontal line, as the change of position would not affect any vertical measurements. Note also, in both Figs. 22 and 24, that the right-hand corner of the eye does not

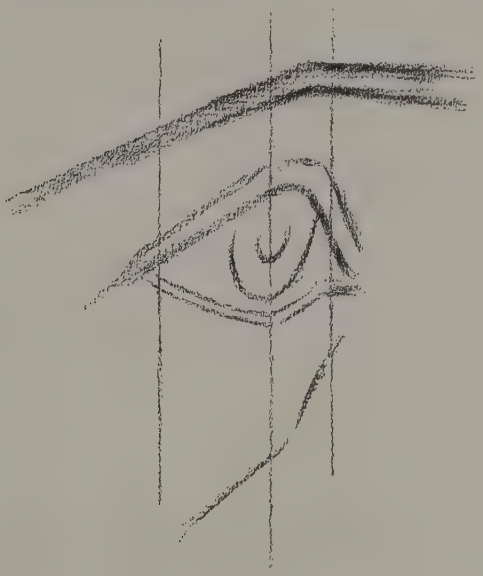

Fig. 24

close completely between the upper and the lower lids, as this is the side next to the nose and contains the little tear gland that in nature prevents these two details from closing together as tightly as the outer corner of the eye.

49. It is very important to practise these simple outline drawings repeatedly and to observe in persons the characteristics that have been herein pointed out. The slightest change in the direction or curvature of any line of these features will change the entire expression of the feature itself and sometimes of the whole face in which it is situated. On the eye and the mouth depend all changes of expression that one is capable of giving to

the human countenance, except a few minor expressions on which the nose is dependent. Much time devoted to these exercises will be of infinite value in proceeding with the more complicated studies. When these drawings are completed, insert the title above, and the date, name, class letters and number, below the drawing plate, as usual, spray the entire drawing with fixatif, and send it to the Schools for criticism.

DRAWING PLATE, TITLE: BLOCK FORM OF HEAD

50. On a sheet of drawing-paper of the same size, and having a border line as before described, make three drawings from the cast showing the block form of the head in the three views: full face, profile, and three-quarter. These three drawings should be made after the drawing plate has been divided into three vertical panels with light pencil lines, in the centre of which should be drawn the block drawing in each of the three positions. This drawing should be executed directly from the cast, but reference to the previous drawing plate, in order to get characteristic details of the eye and mouth in the three positions, will help greatly in drawing these forms.

51. Hang the cast in a good light, so that the shadows fall below and toward the right side. If it is hung near a window, it is best to shade the lower part of the window slightly and place the drawing table with the window to the left and the cast in front. The cast should be not more than 6 or 8 feet away, so that when the arm is extended to obtain the pencil measurements heretofore spoken of, the full length of the cast of the head from the crown to the chin will measure approximately $3\frac{1}{2}$ inches. The width at its widest portion will then be about $2\frac{3}{4}$ inches. These measurements should then be doubled, so that the head on the drawing plate will by pencil measurement be about 7 inches high. Determine these proportions by pencil measurements, and do not adhere to the measurements here given unless the proportions by pencil measurement vary so greatly that the block drawings cannot be contained within the panels on the drawing plate. Should this be the case, change the position of the

drawing table somewhat and move farther away, so that the width of the head may be drawn within the limits suggested.

52. Although all proportions should be obtained by pencil measurement, it is well that the general proportions of the features to the rest of the face should be understood. In the first place, the average head may be considered as one-eighth the height of the body in the male figure, and one-seventh the height of the body in the female figure, and from the chin to the roots of the hair is four-fifths the height of the entire head. Therefore, in the present case, should the drawing of the entire head be 7 inches in height, it will be $5\frac{3}{5}$ inches from the chin to the roots of the hair. The face from the roots of the hair to the chin may be divided approximately into three equal parts, the uppermost marking the lines of the eyebrows, the next the end of the nose, and the last the chin. The entire width of the head may be divided into five equal parts, each part being equal to the width of one of the eyes, and the space between the eyes, and the spaces on each side, each being equal to the width of the eye.

53. Full Face.—Now proceed to set out the general lines of this block form of head in full front view, as shown in Fig. 25. The general outline given to the eyes is smaller, but in the same proportion to that explained in connection with Fig. 22, the eyebrow being slightly flattened and more angular toward the outside edges in the block form than in the free rendering shown in Fig. 22. The indentation from the line of the eyebrows to the top of the nose casts a small shadow, and this should be carefully outlined, while two nearly straight lines mark the sides of the nose down the centre of the face. The end of the nose is broader than the middle, or bridge, and the two side lobes, where the nose itself enters the cheeks, extend on each side and mark the broadest part of the nose. The mouth should then be outlined somewhat as in Fig. 19, care being taken that it is properly proportioned, as can be determined by pencil measurement ; and the line under the lower lip marking the indentation of the chin so placed that it would form, if continued, a slightly flattened circle where it joins the under curve of the chin.

54. By closing the eyes slightly, so that the cast can be observed between the lashes, a great contrast between the

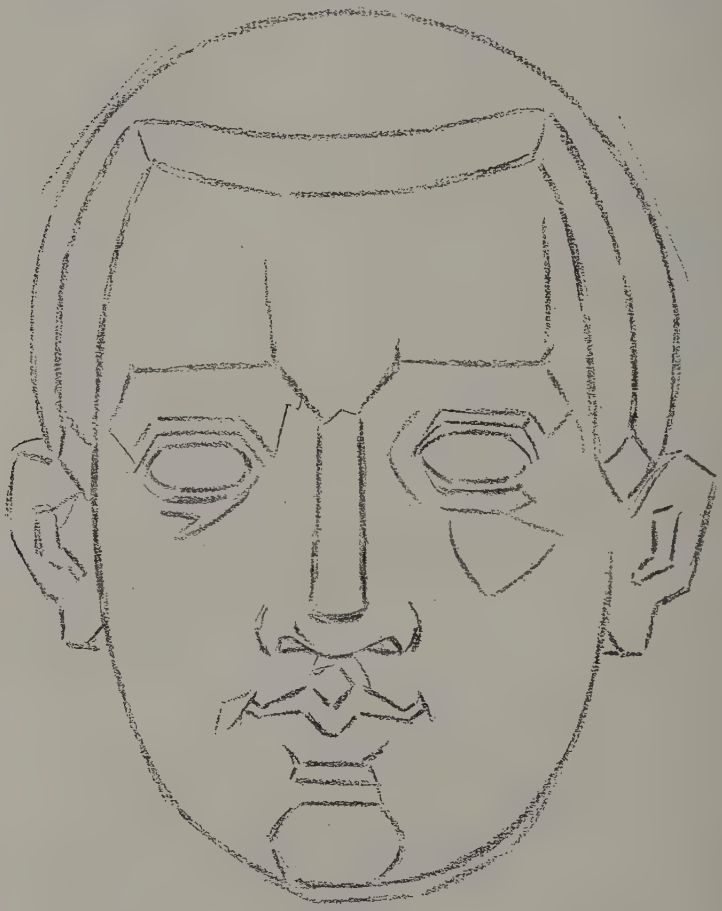

FIG. 25

lights and shades of the cast will be observed, and the lines of the shadows caused by the various features can be outlined on the drawing plate, as shown in Fig. 25, and the shaded surfaces

rendered as shown in Fig. 26, although they may appear to be more varied and softer, as shown in Fig. 27. However, it is

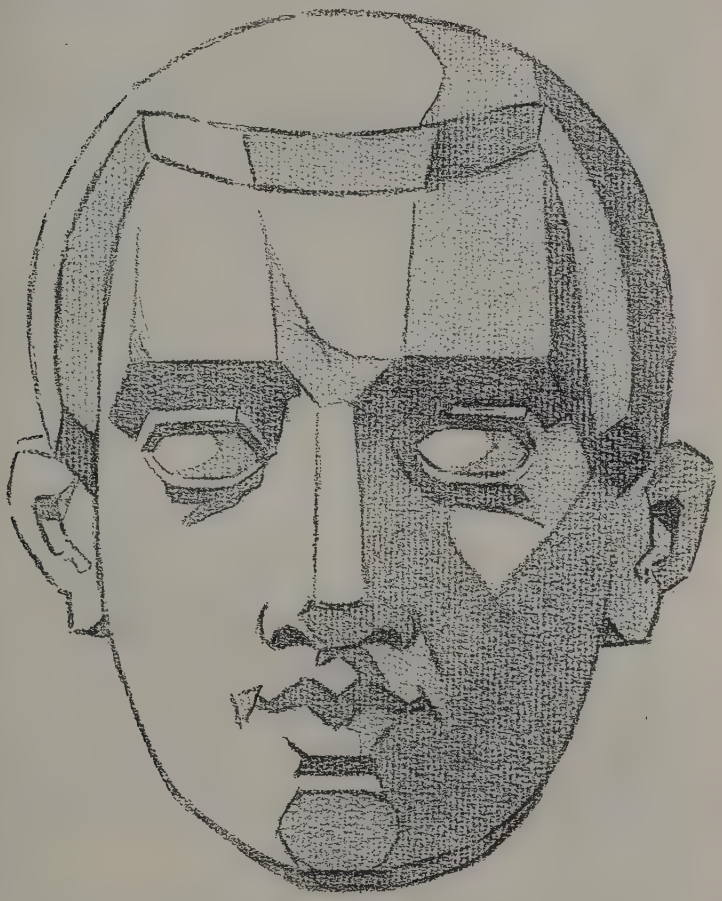

Fig. 26

better at present to render all values in an even tone and leave the gradation of tones until later. If the cast is hung somewhat above the eye, the line marking the roots of the hair will

be almost straight, but if nearly on a level with the eye, this line will curve upwards. Slightly curved lines mark the hair on the sides where it rounds down to the tops of the ears. The ear extends from the line of the eye to the bottom of the nose,

Fig. 27

and in full front view appears somewhat as shown in Fig. 28. In shading the various flat surfaces of which this cast is composed, it is important that an even tint should represent each part of them. Softness and detail are not desired in this drawing, as a simple block representation is all that is required.

When this figure has been rendered satisfactorily and the separate features have been studied to see that they are in proper proportion to the cast and possess all the individual characteristics pointed out for the rendering of the previous drawing plate, carefully cover the other two panels of this plate and spray the finished drawing before taking up the rendering of the second figure on the plate, which represents the block cast in profile.

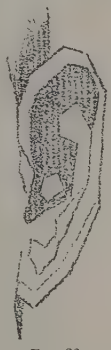

Fig. 28

55. Profile.—Light horizontal lines may be drawn from the top of the finished figure across the other two panels of the plate to fix the position thereon of the main features, as the turning of the cast in profile will not change or foreshorten the apparent length of these features. When the cast is so turned, it will face the window or source of light, and the front of the face will appear, if the eyes are partly closed, brilliantly illuminated, while the sides of the cheek, temple, and nose will be in partial shade.

56. In this drawing of the cast, a line should be drawn approximately representing the angle of the forehead, as shown in Fig. 30, and the relation of the line of the nose to this construction line should be carefully studied. Another line from the end of the nose, touching the chin, should be carefully drawn, the angle being studied from the cast itself. The outline of the profile should now be carefully sketched and the edges of the shadows indicated thereon, while the eye and mouth are carefully rendered in accordance with the suggestions made in the drawing of Figs. 20 and 23. The ear in this drawing will appear more as shown in Fig. 29, but the back part and inside will be the only parts that are in strong shadow. The line of the hair at the forehead will curve upwards or be straight, as in the previous case, according to the position of the cast, but the line should curve out toward the temple and fall slightly below the top of the ear at the side.

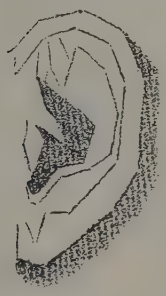

Fig. 29

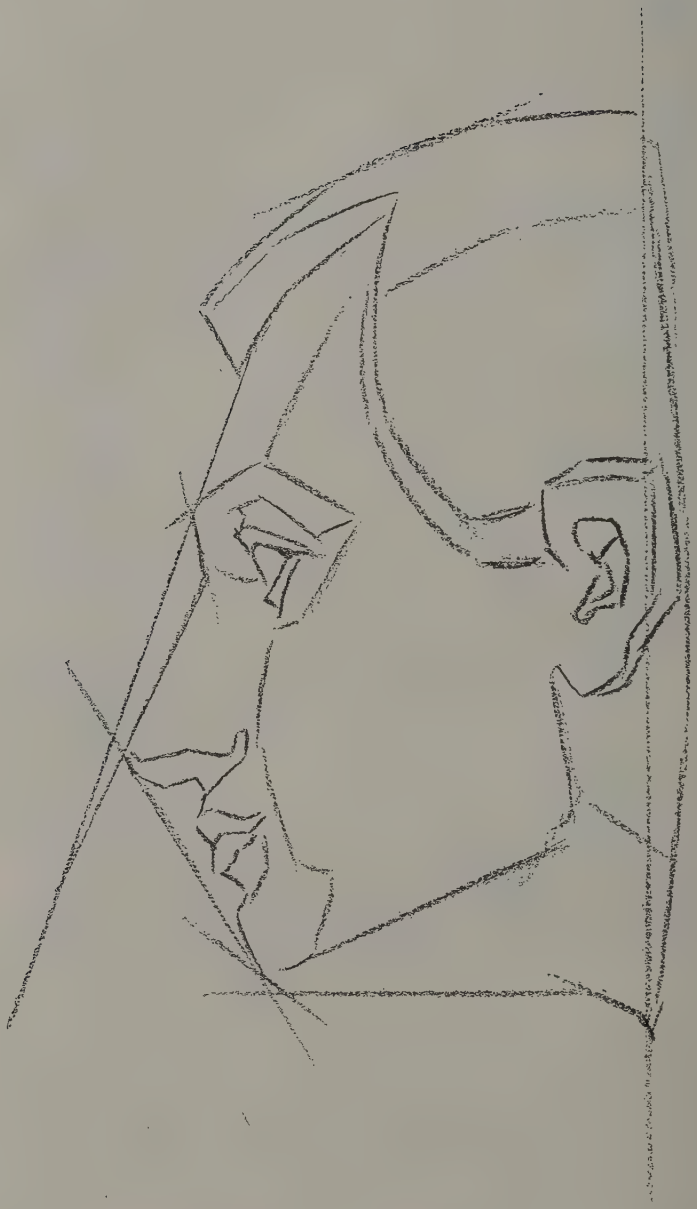

Fig. 30

57. The details of these figures will vary, according to the position in which the original cast is placed, and particular atten-

Fig. 31

tion should be given to the rendering of the drawing from the cast itself rather than from the illustrations in the text. Use the

text illustrations as freely as may be necessary, in order to get ideas of shape and position, but do not copy illustrations in making drawings. The shaded drawing of the profile view will appear as in Fig. 31, where the planes are sharply outlined, but

Fig. 32

in Fig. 32 the planes are not so clearly defined and the cast must be *searched* for these lines of limitation. Endeavour to study from the cast until the points that are emphasized in the text illustrations are seen in the cast. When completed as the plate

this lower should be sprayed with the fixatif in the same manner as before described.

58 **Three-Quarter Head.**—The last figure is the most difficult of these three examples, and will vary from the illustrations

Fig. 33

given in the text in connection with it, according to the manner the cast is turned from the last position. It should be hung, as shown in Fig. 33, so that rather more of the full face than the profile is seen, and the best guide is to turn it away from full face so that the corner of the farther side of the mouth is not quite

visible. This will bring the mouth in the cast, and one eye, in the position shown in Figs. 21 and 24. The line of the forehead

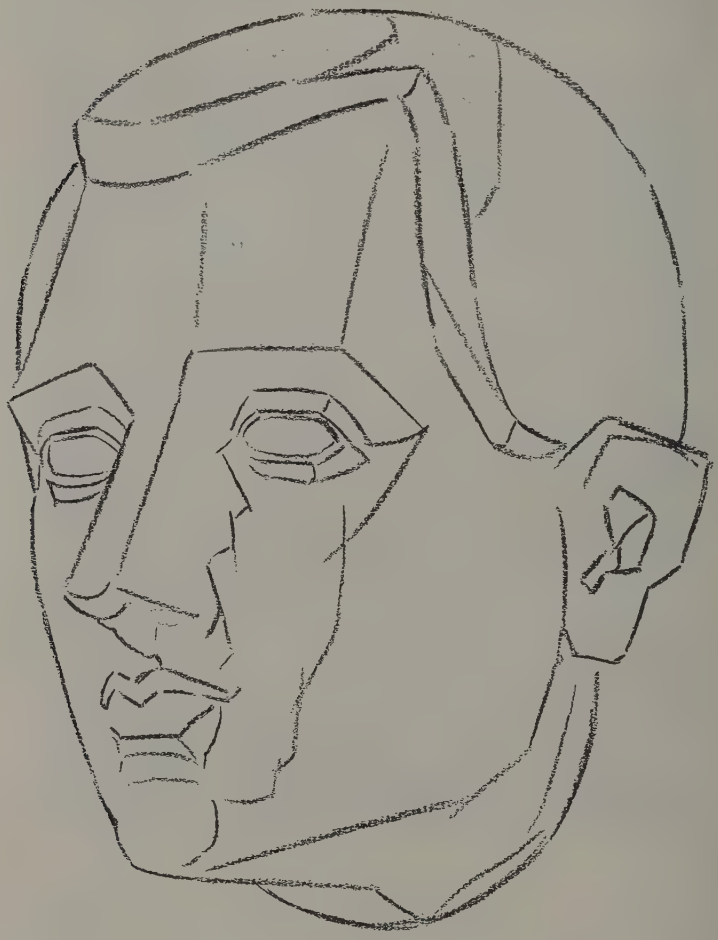

Fig. 34

will not now be continuous down the bridge of the nose, but will reach to the outer visible extremity of one of the eyebrows,

and a portion of the eyelids of that eye will appear. All the features possess the foreshortened or perspective aspect, and

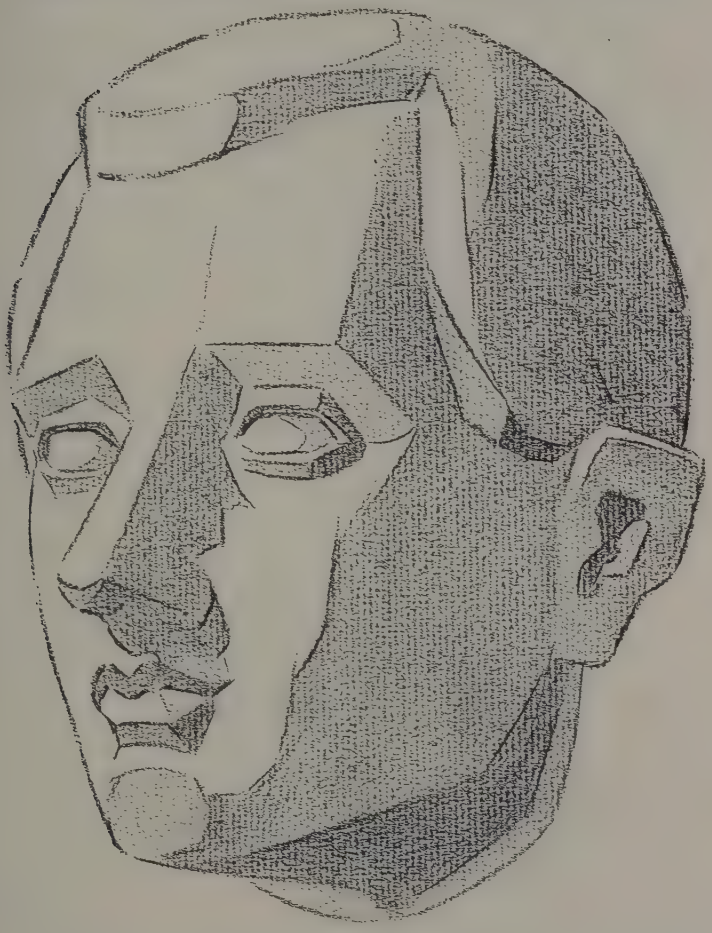

Fig. 35

each should be studied carefully before attempting to outline it on the drawing sheet.

59. First draw the outlines of the planes of shadow, as shown in Fig. 34, and then work in the even tones that represent these planes. In working on this figure, each feature should be considered for a while as a separate problem in itself. Sometimes it will be found desirable to make separate studies of the eye, nose, and mouth before attempting to draw same in the face, but when thoroughly understood do not hesitate to draw them in with bold lines, taking pencil measurements wherever necessary to fix the position of the features. Also study the drawing from time to time, in comparison with the cast, to see that the renderings approach as closely as possible to the form. The outline of the shadows should not be attempted until all the features are properly in place ; then the shades may be rendered lightly in an even tint, to finish the study.

60. More can be learnt by studying the drawing for faults and defects than by reading the text for specific instructions. Learn to draw what you see and determine if your own drawing represents what you see, or, if it does not, wherein it fails. Work slowly from point to point, erasing as little as possible, keeping the crayon pencil sharp enough so that the lines may be placed exactly where required, but by no means as sharp as required for ordinary pencil drawing. Crayon rendering aims to secure broad effects, and in the three drawings on this plate nothing should be represented but a series of flat surfaces—*planes*—that join each other to make up the characteristics of the human face. Once understood as to their position and form, these planes may be easily varied and softened into one another, so that the general softness and characteristics of the individual face can be represented in close portrayal or as in general portraiture, or as in exaggerated portrayal, as in caricature work. It is far more important that the flat, plain surfaces of the block forms be well understood than that the subtle curvatures of a finished form be attempted.

After executing the three figures and spraying the plate to preserve them, the title, name, date, class letters and number should be entered in their usual places, and the plate sent to the Schools for criticism and correction.

DRAWING PLATE, TITLE: BLOCK HAND

61. With this plate, which is to be of the same size as plates before described, with border line, and is to be divided into

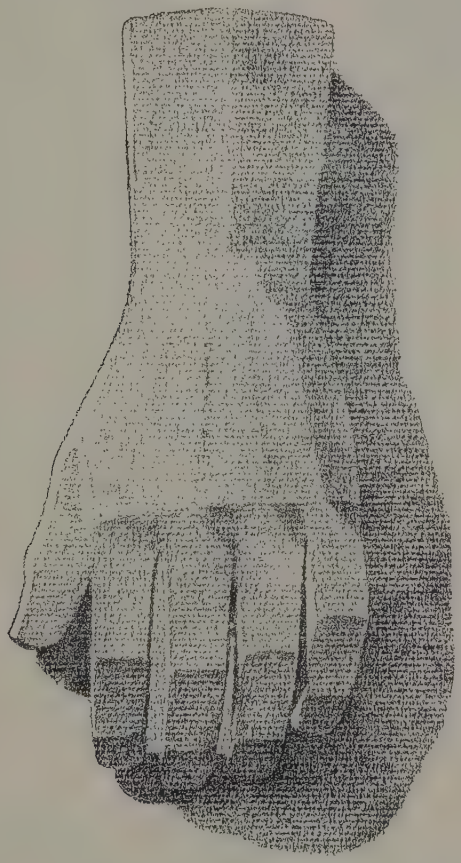

FIG. 36

two equal rectangles by a line drawn $8\frac{1}{2}$ inches from and parallel with the left-hand border line, which is 13 inches long, the cast

of the block hand should be drawn in two positions, one hanging on the wall, in the same light that the head was placed, as shown in Fig. 36, and the other lying on the table some distance in front, in the position shown in Fig. 37. In the first of these positions, which is to be drawn in the left-hand rectangle of the drawing plate, the form of the wrist should taper from where it joins the forearm to its narrowest part and then gradually spread out to the lines of the fingers. The cast of the block hand should be hung about 6 feet in front of and above the eye, or so that the pencil measurements indicate its full length as about $4\frac{1}{2}$ inches. These measurements should be doubled in proportioning the hand on the drawing plate, so as to make the hand about 9 inches long.

Fig. 37

62. In drawing this block form, the whole should be treated as a series of absolutely plain surfaces, as shown in Fig. 38, no attempt being made to render the undulations or curvatures from one surface to another or to cast shadows any deeper than those expressed by an even tone to show the planes at different

angles. In this position the left side of the hand will be in full light, and the right side in full shadow. The outline should be carefully sketched and a central line drawn down the fore part

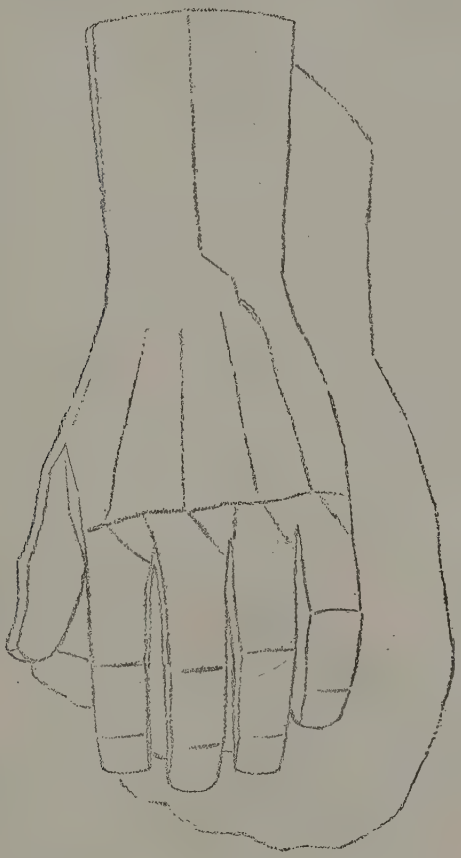

Fig. 38

of the arm to limit the intersection of the two planes that form the surface of this arm. These planes, it will be observed, divide into four, the intersections of which form the knuckles at

the fingers. The shading on these planes should be expressed as deepening slightly in tone as the back of the hand rounds away from the light.

63. The fingers are each divided into three planes: from the knuckle to the middle joint, from the middle joint to the last joint, and from this joint to the end of the finger. These three planes will each be expressed by a different depth of shade. Observe the slight taper of the fingers from the knuckle joints to the ends, and also the tendency of the little finger and the third finger to curve slightly toward the centre of the hand. The thumb in this position appears nearly in profile, and its two visible joints mark the intersection of the planes that may tend somewhat toward a concave surface in order to give emphasis to these joints. The left side of the thumb will be in full light, while the side toward the student will show a slight shade.

The positions, outlines, and depths of these shade tones can best be studied by closing the eyes slightly. The drawing should be rendered in bold lines, without any attempt at fine finish, simply as a study of the intersection of these planes. When complete, the cast of the hand should be removed from this position and laid on the table, about the same distance in front as that in which it was hanging, but below the eye, and turned so that a line from the eye would pass across the right-hand corner of the forearm and over the base of the thumb. This will give a foreshortened view of the hand, somewhat as shown in Fig. 37.

64. The planes may now be represented, as in Fig. 39, after outlining, by shading, as before, but the outlines of the planes should be so light and delicate that after the shading is placed they will practically disappear and the entire block form be represented by a series of shades. The outline may be delicately represented on the left and lower side of the wrist and forefinger, as there is no shadow there to distinguish these points from the other surface. The two planes that intersect on the left side of the wrist may also be separated by a light line, as they are practically of one tone and should not be represented by different tones.

65. The principal points to be observed with the block form in this position are that the fingers do not extend from the knuckles in exactly the same positions, the first and third fingers being slightly higher than the middle finger and the little finger being slightly higher in its middle joint than any of the others. The cast may be placed so that the end of the first finger becomes quite invisible behind the second finger, or it may be turned so much that the full end of the first finger is visible. These points should be carefully studied from the cast, and not from the illustrations given in the text.

FIG. 39

Having rendered this figure in its even tones, the title should be placed above, and the name, date, class letters and number in their usual places on the lower part of the plate, and the whole sprayed with fixatif and sent to the Schools.

DRAWING PLATE, TITLE: FEMALE HAND

66. For this plate the plaster cast of the female hand should be used, hanging it in the same position as the block hand for the former plate. The rendering of this drawing, however, will

be considerably more difficult, as the planes of light and shade are not so clearly designated, owing to the finished character of the surface. However, by slightly closing the eyes the deep shades can be readily distinguished from the high lights, and the line of demarcation between them can be studied and indicated on the drawing. The cast should be placed at such a distance that the pencil measurement of the length will indicate about $4\frac{1}{2}$ inches, and this should be doubled for the proportions on the drawing plate. The drawing plate, inside the border line, may be divided into two panels by a vertical line. In the left panel, render the drawing as a block drawing similar to that shown in Fig. 40.

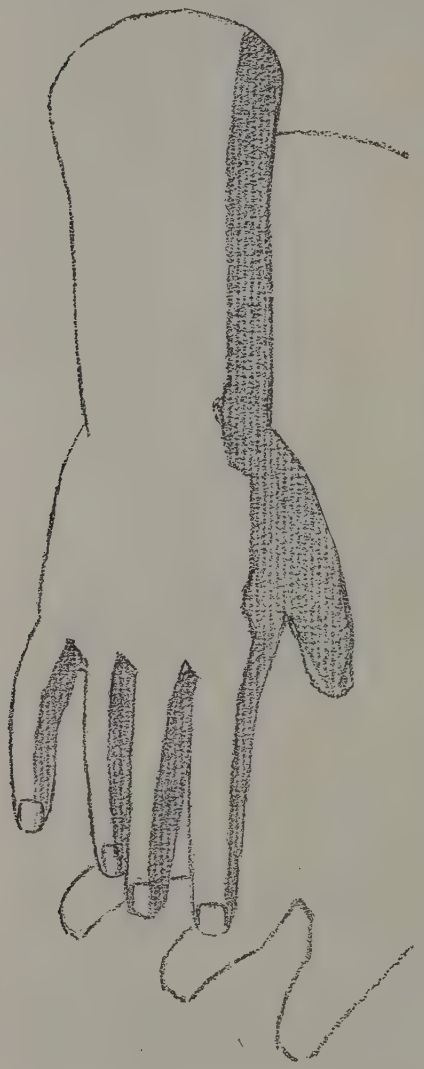

FIG. 40

67. First carefully draw the outline of the wrist and hand, noting that curved

Fig. 41

guide lines can be drawn to fix the positions of the points of the fingers, middle joints, and knuckles. The fingers themselves should then be very carefully drawn in outline, and also the extended thumb. Note carefully the subtle curve of the base of the thumb where it intersects with the wrist line at an obtuse angle, and then indicate the positions of all the shadows so as to render them in a flat block form similar to Fig. 40. Every peculiarity in the block form should be slightly exaggerated, as these exaggerations can be easily toned down in the rendering of the finished drawing, Fig. 41, and they help to fix individual points. For instance, the intersection of the little finger with the back of the hand may be indicated by a much sharper indentation than appears on the cast, and the lines connecting different parts of the drawing may be flatter and straighter than appear on the cast, in order to reduce the lifelike form to a block form, as shown in Fig. 40.

68. When the shading is applied to various parts, it may also be accentuated where the lines of direction change. The right-hand side from the wrist to the end of the forefinger will be entirely in shadow, and the line from the forearm to the wrist may be rendered nearly straight. From the forearm to a point below the knuckle of the forefinger will be another straight line, and from this point to the knuckle and thence to the middle joint and end of the finger the shadow may be drawn out by a series of short, crisp, straight lines. This same treatment may be followed with the other fingers, and the whole surface should then be shaded to indicate the block form, as in Fig. 40. When this form has been rendered, it should be carefully sprayed to prevent its becoming rubbed or blurred ; then proceed to work the same problem in the right-hand panel of the drawing plate.

69. The second rendering of this drawing should not be made from the first rendering, but from the cast. Every effort should be made to go directly to the point desired and render the second work more satisfactorily, and with less alteration and change than was accomplished with the first. When it is entirely finished the two should be compared, to see if there has been any improvement in the second over the first. Having rendered the

second one in block form, now proceed to round off the shadows to give the appearance of a finished drawing, as shown in Fig. 41.

The lines of demarcation between the shadows should be so light that they may be easily softened and blended into the high light by touching lightly with a piece of stale bread, and the shadows should be deepened to the right where the surfaces curve farthest from the source of illumination. Observe, in Fig. 41, that the darkest part is not the part in reality the farthest to the right on the drawing, but is midway, or a little more than midway, between the highest light and the extreme right-hand outline. For instance, note that on the fingers the darkest portion is in close proximity to the high light, whereas the portion to the extreme right-hand outline is considerably lighter. This is due to the fact that the white surface of the cast reflects light back on the other fingers and softens up these shadows considerably.

70. On the wrist, the point next the wall at *a*, Fig. 41, is considerably lighter than the point at the wrist *b*. This is due to the fact that the light falling on the wall is reflected back to *a*, but owing to the curvature of the wrist *b* is more distant from the wall and does not receive as much, if any, of this reflected light. In the same manner the inside of the thumb at *c* becomes illuminated by reflected light from the opposite forefinger, and the inside of the little finger and the second finger at *d* and *e* are illuminated by reflections from the adjacent fingers. Study these subtle shades carefully. They may not appear exactly or anywhere nearly as they do in the illustration, Fig. 41, as they will vary according to the lighting and local conditions.

All this work can be rendered with the crayon pencil, and when finished, the title, name, date, etc., may be placed as usual, and the drawing sprayed a little more thoroughly than in the previous cases, as the deeper shadows show a tendency to rub unless thoroughly sprayed. Care should be taken, however, not to get too much fixatif on the surface of the drawing, as it not only disfigures it, but is likely to cause it to stick together when rolled up. Roll up the plate very carefully and send it to the Schools for correction and criticism.

FIG. 42

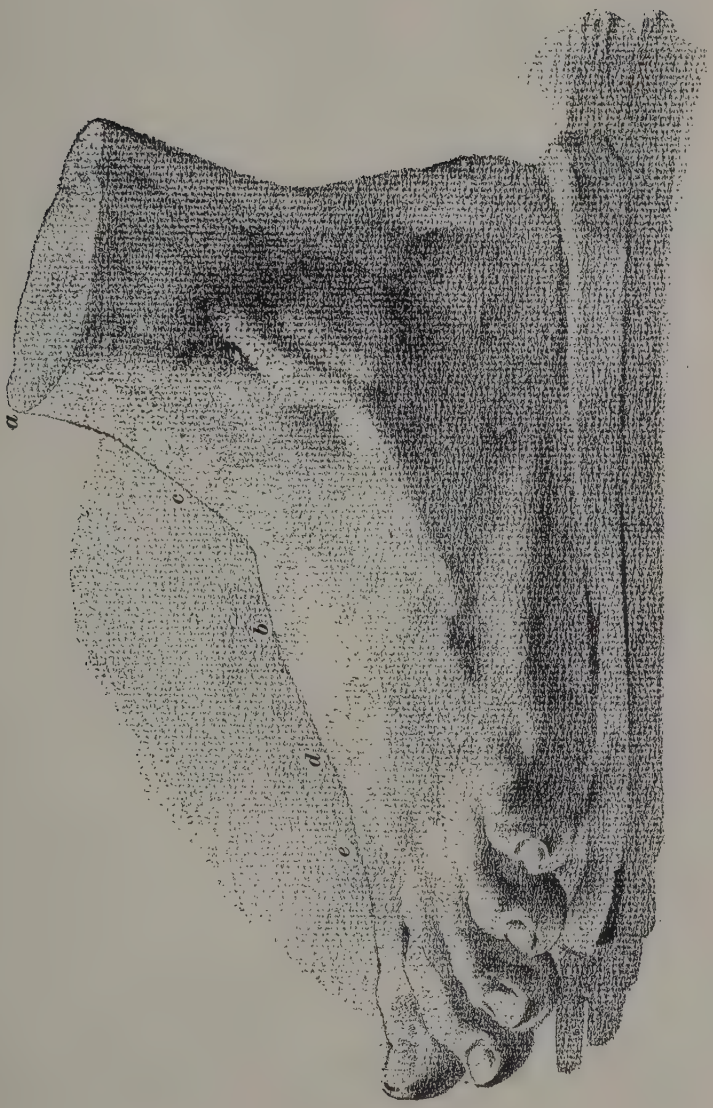

FIG. 43

DRAWING PLATE, TITLE: FOOT

71. In rendering a drawing plate of the block foot, there is little to be said in addition to what has already been explained in connection with the drawing of the female hand. In general illustration, and even in drawing from life, there will be fewer occasions to render the naked foot than the hand. It is necessary, however, to be familiar with the shape and characteristics of this detail, so as to better appreciate the form when rendering feet enclosed in shoes, or, as is more often the case, in sandals.

The aim of study from the cast should be to get the best general effect with the fewest number of lines and the least amount of work. A drawing that is constantly fussed over and changed loses character. It is better to spend more time in studying the subject and less time in putting it on paper than to hastily sketch some detail that must be almost immediately rubbed out because insufficient preliminary thought was given to that detail.

72. In drawing the foot in its first block form, as shown in Fig. 42, it will be necessary to stand it on a table, slightly below the eye, at such a distance that the pencil measurement will make it about $4\frac{1}{2}$ inches long, which can be doubled to 9 inches in rendering the plate. The height should then be determined, and the base on which the foot rests. The ankle, instep, and heel should be indicated by a few bold lines, greater care being used to outline the subtle incline from the height of the instep to the point of the big toe. The positions of the other toes, relative to the block on which the foot rests, should then be indicated by a series of small curves, as shown at *a*, *b*, *c*, and *d*, and the outlines of the toes then drawn carefully to where they join the top of the foot. The line of the shadows should be indicated as shown in Fig. 42, and all the shaded surfaces rendered in an even tone to express the dark side of the cast. This being done, the work should be sprayed and that part of the plate covered over until, as in the previous case, the same exercise is repeated immediately under this, in order to get additional practice in the rendering of the block form, and also prepare a block form that can be worked up into a finished cast drawing.

73. In finishing up this second block form, more care should be given to the outline of the front of the ankle and the top of the foot. The straight, bold lines that in Fig. 42 characterize the work may be subdued into gentle curves, but these curves should be studied carefully in the cast, and it will be soon seen that the sweep from *a* to *b* in Fig. 43 is not an even, unchanging curve, but a combination of curves, and that at the point *c* it is nearly flat and in contrast with the other curves appears almost convex, and at *d* and *e* it comes into fullness again. These subtle variations in the curvature of surfaces make drawing from the human figure most interesting and most difficult. The eye must become well trained to observe these variations in the cast, where they are fixed and unchangeable, in order to detect the much more intricate and difficult curves in drawing from the living figure, where fatigue will cause change of position and consequently a constant varying of outline.

74. In drawing from the cast, take time to study it and determine all the details that are to be expressed before executing them on paper, so that when drawing from the human figure, familiarity with the cast forms will make it simpler to work rapidly in order to get general impressions ; excessive time spent in any one place to study details would find the general pose changed slightly and the finish of the general outline might represent the figure in a different position from that in which the drawing was started. These points should be borne in mind by the student when he is working from the cast, in order that the purposes of studying from the cast may be properly understood.

Having completed the drawing of the foot in its two forms, the title, date, name, class letters and number should be entered as usual on the plate, and the latter sprayed with fixatif.

DRAWING PLATE, TITLE : THE DRAPED FIGURE

75. In Fig. 44 is shown a reproduction from a photograph of a piece of statuary : The Venus of Milo. In Fig. 45 is shown the general block outline that should be used upon which to build

FIG. 44

Fig. 45

§ 29

Fig. 46

up the crayon drawing of this figure. After completing the preceding exercises, one should be able to reproduce this drawing so that it will appear as shown in Fig. 46, with the light-and-shade values rendered about as represented. It will be observed that liberties have been taken with these light-and-shade values in Fig. 46, in comparison with the photograph, in order to more clearly show the modelling of the parts, thus illustrating the fact that in drawing from a photograph it is not always necessary to follow every detail of light and shade that is presented. One must be familiar with form and know what is necessary, in order to secure the most pleasing results.

Draw this partly draped figure as a regular drawing plate, making it about 15 inches high ; and after placing the title, date, name, etc., in their usual places, spray the drawing with fixatif and send it to the Schools for criticism.

DRAWING FROM COMPLETE CASTS

APPLICATION OF PRINCIPLES

76. The application of the general principles of drawing from the cast is shown by means of Figs. 47 and 49. The drawings of these two examples shown in Figs. 48 and 50 are typical of a good and workmanlike style of drawing from objects of art, worthy of study, that are situated in a public place. It shows a systematic method of setting out the main lines, roughing in portions of the detail, and finishing off completely important particulars, such as the head and upper part of the body of the main figure. By this means the artist is enabled to obtain and bring away with him, in the necessarily limited time he will have at his disposal, information sufficient to recall to his mind the main impressions received from the design.

77. In Fig. 47 is shown a reproduction from a photograph of one of the celebrated bronzes on the parterres of the Château of Versailles, France, and in Fig. 48 is shown the artist's drawing from same. It will at once be noticed that the pyramidal shape

Fig. 47

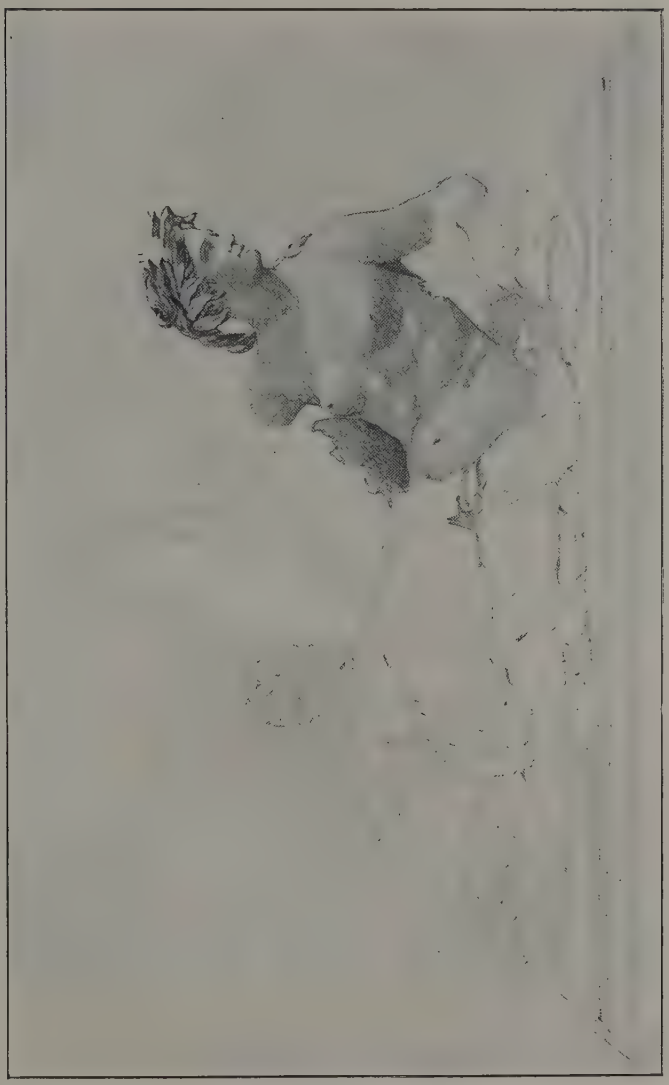

Fig. 43

of the general composition has first attracted attention. This general outline of the form of the group has been indicated by the delicate lines which have been first roughed in, fixing the main outline of the mass as a whole. If one lacks practice, the proportion of the various lines enclosing this mass can be obtained by pencil dimensions as before described, but one thoroughly conversant with this style of drawing could easily sketch in the outline quite correctly without the aid of pencil dimensions.

78. When the delicate lines enclosing the composition have been correctly obtained, the mass should be subdivided and lines of direction drawn, connecting the main points of the two figures. Such lines are drawn from the right hand of the child to the right hand of the female figure, and from here to her head and the elbow of the left arm. Other lines can be easily traced. When a sufficient number of such lines have been inserted the outlines of the limbs can be indicated. Further work on the drawing will now be devoted to the use of these setting out or guide lines, as a means by which to draw the outlines of the body and limbs. Most of the drawing will be left in this state, but to enable the artist to recall the impressions received of the more important parts of the group, certain parts, such as the body and head of the female figure, are worked up in detail.

79. In Fig. 49 is shown a reproduction from a photograph of one of the works of the celebrated sculptor, Mino da Fiesole, representing the tomb of Conte Ugo Marchese di Toscana in one of the churches in Florence, Italy. In Fig. 50 is a drawing of this tomb indicating the best method to adopt in setting out the main outlines. The tomb on the whole is of rectangular form; it is obvious, therefore, that the proportion to be allotted to the sarcophagus or coffin itself, and to the long panel beneath it, should first be determined. After this is settled, and its outline has been faintly indicated, it is a simple matter to fill in the details, working step by step, as before suggested, and from the outer margins inwards. The aim in making a drawing such as this should be to place on record information important enough to affect the design of the whole. Draw the various lines with

FIG. 49

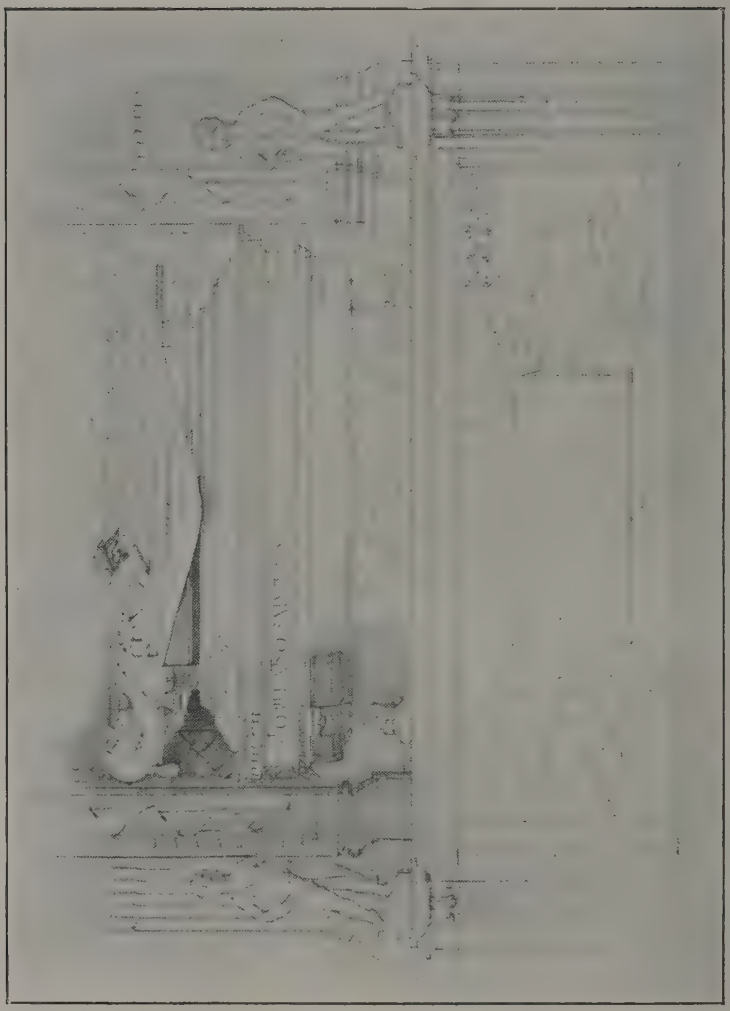

Fig. 50

determination and directness, in such a manner that they are distinct as to their meaning and correct as to proportion and direction. As far as possible, avoid the necessity of rubbing out. Seek the lines of composition in the original, the undulating imaginary lines which run through a figure from head to toe, or through the main lines of a composition, and learn by correctly placing these lines to obtain the direction, or the action, the artist in his original composition has desired to express. To obtain the artistic finishing of the drawing by correctly building upon these lines will then be only a matter of practice.

BLACK-AND-WHITE DRAWING

PEN-AND-INK RENDERING

GENERAL INSTRUCTION AND EXAMPLES OF WORK

INTRODUCTION

1. Definition.—The term **black-and-white drawing** applies to the treatment of a drawing in light and shade. A landscape, a portrait, or a perspective of a building may be drawn in outline, but to give it full pictorial effect the lights and shades should be indicated either by flat washes of colour or by a series of closely placed lines drawn with a pen. The representation of light and shade by either method is termed *the rendering of the drawing*, and is entirely independent of the outlining of the drawing itself, although the outline is often first drawn in pencil. *Light* and *shade* tend to give the semblance of reality. Objects in nature are seen as spots or masses of different colours, differing also in degree of lightness or darkness. A drawing may be rendered in colour and shaded, or in colour only, as is done by the Japanese, or it may be rendered in simple light and shade, a common method of which is with pen and ink. This Section will treat of rendering in light and shade only, both by means of pen and ink and by means of the brush in *monochrome;* that is, a wash of one colour.

2. The successful rendering of a drawing does not depend solely on the mere ability to draw outlines. The eye and hand

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may be easily trained to observe outlines and to depict them on paper, but it requires a more careful observation to judge of the relative amount of light and shade on each part, especially as they always appear exaggerated when contrasted with one another; that is to say, a bright object will appear brighter against a dark ground than it would if surrounded with other bright objects. A deep shadow, such as the interior of a doorway, will appear deeper and less transparent if the outside of the building is in full sunshine. In rendering a drawing, one must study these phenomena, and use the knowledge so gained in one's work. So, also, if two shades are contrasted, the lighter one will appear lighter and the darker one will appear darker than is really the case. This happens with the drawing as well as in nature, and while it is sometimes disturbing, it is more often a serviceable means of producing desirable effects.

MATERIALS USED

3. Outlining. The outfit required for pen-and-ink rendering is simple, but each detail should be the best of its kind. If a careful preliminary pencil drawing is made, it should be finished in outline with a finely pointed pencil of good quality, and nothing left in the way of outline to be afterwards executed with the pen. When the pen does any outlining at all, it simply traces the outline over the pencil line, but as a rule it will be found that outlines are ignored in pen drawing and that the pen is used simply to express masses of light and shade, leaving the outline to take care of itself.

4. Erasers. A soft rubber eraser should be used to correct errors made in the pencil drawing, but should be used as little as possible, as every time the surface of the paper or board is touched with the rubber a certain amount of its prepared surface is destroyed, thus tending to the running of the ink when it is applied. A sharp knife may be used for scratching out mistakes in the inking, but the knife should be used very sparingly, as it is very difficult to work over a scratched spot and produce a neat line.

5. Paper. For paper, a good quality of Bristol-board should be used. The surface must be smooth and well calendered, so that there will be no tendency for the ink to spread. Almost any smooth paper with a hard surface may be used, but it should be tested by drawing the pen across the surface to see that it moves freely and smoothly and leaves a fine unblurred line of ink. Experimental rendering may be tried by placing over the pencil sketch a piece of tracing paper, and rendering the drawing on the tracing paper without the outline. Several systems of rendering can thus be experimented with before the final one is attempted. The pen drawing on the tracing paper can be mounted on cardboard and preserved, if desired.

6. Pens.—Pens of various brands are made and sold specially for drawing, and although certain of these are excellent in the hands of an experienced draughtsman, it is not at all necessary that any special make should be used during study. Gillott's No. 303 will make as fine a line as is necessary or desirable in a pen drawing that is intended for practical work; that is, for work that is to be reproduced as an illustration. Gillott's No. 404 is fine enough for bolder lines, and C. Brandauer's Oriental pen for medium work. An ordinary old-fashioned quill pen is very serviceable for decorative work where a broad rich line having something of the quality of a brush line is desired.

The beginner should not use too fine a pen; probably the Oriental would suit him well, but as he perfects himself in the art of black-and-white drawing he may use a pen making a wider range of line possible, such as Gillott's Crow Quill which, after it has been used for some time, will become almost as responsive to the touch of the artist as a brush. Above all things, pens should not be changed, and one kind should be used until mastered. It should be remembered that even the best of pens is a stubborn instrument. Practice is the only cure for its unwieldiness, and a great deal of practice is necessary to train the hand and the pen to work together in harmony. The pen should be drawn toward the draughtsman when possible, but when it is moved sidewise the pen should be turned so that the under side moves away from the line being drawn.

7. Ink.—Perfectly black ink of any kind may be used for pen drawing. Sepia or brown inks are sometimes used, but are of no importance except for special effects. Black ink is absolutely necessary if the drawing is for reproduction by photo-engraving, and in any case the effect of the drawing is materially damaged by any variation in the colour of the ink with which it is drawn. Several inks on the market give satisfactory results. Among these are Higgins's drawing ink, Winsor & Newton's Indian ink, and l'Encre de Chine Liquide, a French product that is of practically the same value. If preferred, one may make his own ink by procuring a stick or cake of Indian ink, and rubbing it down in a saucer of water, but this is neither as convenient nor as satisfactory as the ready-made liquid inks mentioned.

VALUES

8. Definition.—The term value is used by artists to express the degree of light or shade. In rendering a drawing different values are used; that is, different degrees of light and shade,

FIG. 1

FIG. 2

as, for instance, black, grey (or half tone), and white. These three values may be used to represent simple light and shade. In Fig. 1, where white and grey alone are used, a drawing in two values is given. Values are also used to express differences of

colour in the objects they represent, as shown in Fig. 2. Both considerations enter into the proper rendering of a drawing, but the former alone is occasionally all that is required, and there is a great difference of practice among artists as to the extent to which "colour values" should be employed.

9. The simple rendering of Fig. 1 indicates that the source of light is behind the girl and to the left, thereby throwing her shadow in front and to the right, shading her face and the front portion of her dress. This two-value rendering makes no attempt to show whether the dress is light coloured or dark coloured, or whether the kerchief about her neck is of the same or a different colour from the dress. In Fig. 2, however, the rendering shows that the kerchief is lighter in colour than the dress, and that the dress is lighter in colour than the apron. The position of light is not indicated, as the colour values give sufficient interest. As rendering consists of the expression or representation of these values, it is obvious that a clear conception of them is of the utmost importance. A scale of values should be made and frequently practised, so that it will become familiar.

10. Scale of Values.—A **scale of values** is a gradation from the deepest shadow to the brightest light; that is, a representation of all the shades from black to white. It is possible to make such a scale express so many values between absolute blackness and absolute whiteness, that the steps can be scarcely perceived; but for practical use in pen-and-ink rendering three tones or values, black, half tone, and white, will often be sufficient. This has been shown in Fig. 2, where the apron and hair are expressed in the darkest tone, the dress and water jars in the half tone, and the face, kerchief, and stockings in the white of the paper.

11. A scale of five values should also be practised, however, so as to give power to depict an object more fully than can be done with three tones; but in pen-and-ink rendering a scale of more than five values is difficult to use and seldom necessary. These five values should first be rendered in a wash drawing with the brush, as shown in Fig. 3, where (*a*) is absolute black, rendered with the full strength of the ink; (*e*) is perfectly white,

being simply the colour of the paper; (*c*) should be midway in tone between (*a*) and (*e*), and (*b*) should be midway in tone between (*a*) and (*c*), while (*d*) is midway between (*c*) and (*e*). This gradation of tone should be carefully practised until the eye is satisfied that none of these middle tones lean more toward one of its neighbours than toward the other; that is to say, (*b*) should be just as much darker than (*c*) as (*a*) is darker than (*b*). Having secured these tones in wash, they should be drawn with pen and ink, as shown in Fig. 4. In pen drawing it is seldom, if ever, advisable to use an absolute black. A flat black colour, such as shown in Fig. 3 (*a*), is within the province of brush work, but pen drawing is essentially line drawing, and even the deepest black should not lose this character. Therefore, small specks of white show through it, giving it transparency and characterizing it as pen work, as in Fig. 4 (*a*).

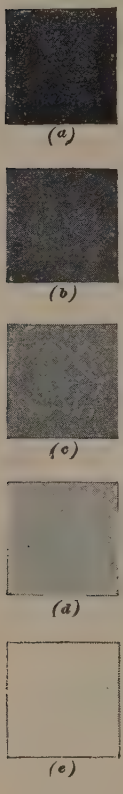


Fig. 3

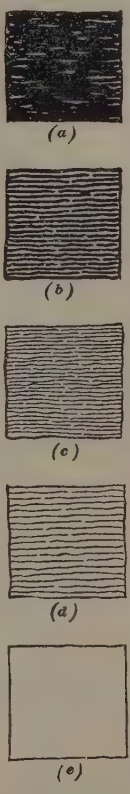


Fig. 4

12. In preparing this exercise, Fig. 4, five squares should be drawn (about 1 inch each) and (*a*) rendered first as the deepest tone. The tone marked (*c*) should then be rendered by a series of moderately heavy lines, spaced about as indicated, in order to give a tone which will be about the same as in Fig. 3 (*c*). The tones in (*b*) and (*d*) can then be rendered to correspond with those shown in Fig. 3 (*b*) and (*d*). Observe that the darker tones are produced by making *heavier* lines and spacing them close together, whereas the lighter tone, as in (*d*), is produced by making *light* lines and leaving more space so that the white paper

shows through and tempers it. The half tone (*c*) is the key to the entire scale, as it must be midway between (*a*) and (*e*). Drawings are usually rendered in such tones as (*a*), (*c*), and (*e*) first, after which the tones (*b*) and (*d*) are introduced, if necessary.

13. This practice of scales of values should be repeated frequently on separate pieces of paper, both with the brush and with the pen. The intermediate values (*b*), (*c*), and (*d*) should always be made separately and then compared with (*a*) and (*e*) or (*c*) and (*e*), as the case may be, to see that they are in equal contrast to the values between which they are to be placed. Any inequalities should then be corrected by making a new wash, and the experiment repeated until the exact tone can be attained the first time. When the eye moves easily and comfortably from one value to the next, a rhythmic progression of values is obtained. This rhythmic progression, or movement, by regular steps of value from light to dark or from dark to light, is one of the most important factors in the agreeable rendering of a drawing.

14. Difference of Technique.—The same value may be obtained either by using fine lines set near together, or fewer or heavier lines set farther apart. The amounts of black and white will be the same in both cases, and the values identical, but the effect will be different. This difference is called **difference of technique**; it is analogous to the difference produced in cloth of the same colour by different methods of weaving. A coarser or finer technique in the shading is often employed to represent different colours of the same value. A difference of technique may be produced also by giving the lines different directions, or by crossing them, which is called **hatching.** It is advisable, wherever possible, to obtain all shadows and tones without adopting cross-hatching, except in rare circumstances; and, when drawing for reproduction, the necessity of keeping all hatching as open as possible must be borne in mind, or the printing will result in a confusion of lines.

15. In the expression of a tone by means of the pen the value is obtained by the grouping of the lines. The depth or darkness

of the tone will depend on the weight, or width of the lines, or the distance at which they are placed from each other, as shown in Fig. 4; in other words, each line drawn is a black line, and the effect of value results from the amount of white paper remaining uncovered by the ink. The dark value may be produced by a multitude of fine lines drawn closely together; this is almost invariably the tendency of the beginner. A much

Fig. 5

better effect, however, results from a more economical method of working, as that shown in Fig. 4 (*a*), where the darkest value is composed of heavy lines closely spaced and recrossing one another at an acute angle. Another tendency of the beginner is to express the lighter values with very thin, weak lines; this is not only bad practice, but it renders the drawing difficult to reproduce as an illustration. All lines in a good pen drawing

must be firmly rendered, and each must be black and full width. Therefore, a light value is best expressed with firm lines drawn a good distance apart, as shown in Fig. 4 (*d*).

16. It is well to know that even experienced artists find it necessary to practise these scales of tone before they start to render a drawing. It takes some little time to tune up the

FIG. 6

fingers so that the pen can be handled smoothly and satisfactorily, and 15 minutes a day devoted to this simple work will do more toward the training of the hand than hours of practice in actually rendering an illustration. In like manner, the most renowned pianists have to practise their scales every day.

17. In Figs. 5 to 7 are shown details, to an enlarged scale, of portions of drawings that illustrate wide differences of

technique. In each figure the rendering of trees is shown, but it will be noticed how very different is the treatment in each case, although they are all by the same artist, D. A. Gregg.

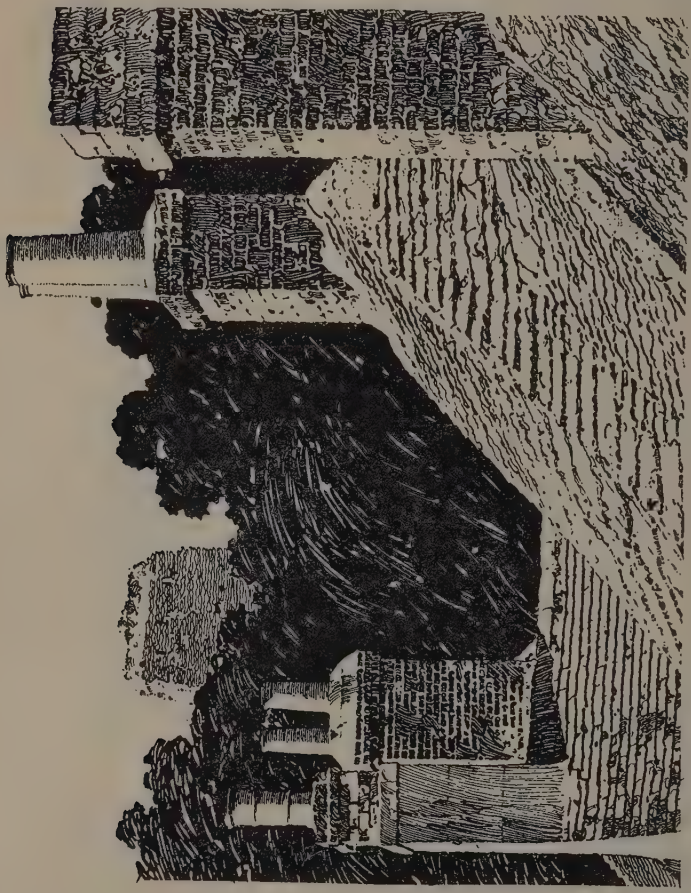


Fig. 7

These figures have been inserted to an enlarged scale so that the methods of producing the effects obtained may be carefully studied. In Fig. 5 the effect of the trees is obtained by a series

of irregular curved lines executed in a manner that to the uninitiated appears careless, but a careful examination will show that hardly a line is superfluous, neither is a line left out that is necessary to give a clear idea of what is depicted. In Fig. 6 a straighter and bolder line is used in rendering trees and less detail is shown owing to the distance the tree is from the eye. A careful examination of the drawing shows that the effect is obtained in quite a different way. The portion of the porch, or veranda, shown gives a good idea of how little detail is necessary in order to obtain the desired effect, for here no outline has been used. The great difficulty with beginners is to leave out detail when rendering a drawing, so Fig. 6 should be carefully studied, as it well shows how much better the whole idea of the effect of detail can be obtained by suggestion rather than by laboriously filling in the mouldings and carving. In Fig. 7 a still different method of rendering trees is shown; this approaches in colour, somewhat, that shown in the scale of values in Fig. 4 (*a*). The depth of colour in these trees shows the lighter rendering of the chimneys and roofs in front of them. These examples should be carefully studied and practised several times, as by this means, better than any other, it is possible to learn how to render different materials and objects, and how to suggest detail and thus produce what is all important, a free drawing.

COMPOSITION

18. Definition.—Composition in a drawing is the grouping of the various parts that make it a picture. Each important detail must be grouped in such relation to every other detail as to produce the most pleasing effect. An illustration or a drawing in which the principal objects are scattered all over it is not interesting. They must be so grouped that the eye either takes them all in at a glance, and realizes that all other objects in the picture are merely accessory, or they must be grouped so that the eye travels naturally from one to the other and easily comprehends their relations. In sketching from nature or taking a photograph, one must first choose a point of view and then decide just what part and how much of the subject should be

included in the picture. In photographic work this is not always an easy matter, and photographs taken for the purpose of illustration frequently require alteration or change of composition by the artist.

19. In practical pen work, it frequently happens that the draughtsman receives a subject to render, in the form of a photograph from nature or a perspective in outline of some building. Here, so far as concerns effects of light and shade, the matter of composition is left entirely with him, and he must determine on the values in which he will render the different parts; he must also use his own judgment for the introduction of such accessories as figures and foliage that may be required. The success of his finished drawing will depend more on the skill he has shown in this composition than on his technique or skill in the handling of the lines themselves.

BALANCE, RHYTHM, AND HARMONY

20. It is necessary to understand and keep before the mind the fundamental principles of composition; that is, to notice and remember what arrangements are the most agreeable. These principles apply not only to pictorial representation, but to every kind of design. In general, composition involves three separate considerations: *balance*, *rhythm*, and *harmony;* and if work is executed in accordance with these principles, it will result in a unity of effect that is satisfactory and restful, because all parts of the picture are consistently related to one another. They should be thoroughly understood and constantly remembered, for they apply not only to pictorial representations, but to every kind of design.

21. **Balance.**—A composition in which the attention is too much scattered lacks interest, and therefore should be so arranged as to direct the eye toward the most important object. But this object should not be too far from the middle of the picture, or the composition will look ill-arranged and one-sided. Hence, if the picture contains but a single object of interest, it should be set somewhere near the middle while several objects of

nearly equal importance should be put at about equal distances from the centre. Several objects of various degrees of importance are naturally placed at different distances. In respect of light and shade the most important thing is value. In a com-

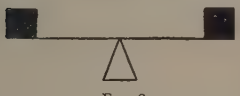


Fig. 8

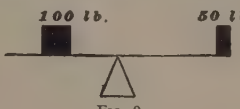


Fig. 9

position of lights, white objects are of the most importance, but in a composition of darks, black objects are of the most importance. In mechanics, bodies of different size and weight balance one another round their centre of gravity; the larger and heavier are nearer the centre than the smaller and lighter. Hence, a composition thus arranged is, by analogy, said to be balanced.

(a)

22. Balance is a principle that everyone understands as a physical law. It is well known that when a

(b)

(c)

Fig. 10

(a)

(b)

Fig. 11

board is balanced evenly over a trestle, as in a see-saw, its centre of gravity must be over the centre of support. It is also known

that if a weight is placed on one end of the board the balance can be maintained only by placing an equal weight on the other end, as shown in Fig. 8. A weight of 100 pounds, placed half-way between the end of the board and the point of support, can be balanced by a weight of 50 pounds placed on the extreme other end, as shown in Fig. 9. In Fig. 10 are shown three rectangles, in the centre of each of which is a spot. These spots are of different shapes, but the balance is maintained by their central position in the figure. In Fig. 11 (*a*) and (*b*) are shown two spots similar to that shown in Fig. 10 (*a*). They are of the same size and shape and are spaced equidistant from the centre; they therefore balance each other in the composition. In Fig. 12 the spots are of different shapes, but are of equal value in light and shade; therefore, being

Fig. 12

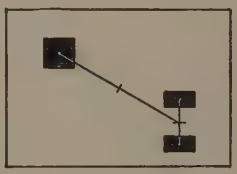


Fig. 13

equidistant from the centre, they balance. In Fig. 13 are shown three spots, two of which are each half the size of the third; these two, being together equal in value to the third one, satisfactorily balance with it when spaced the same distance from the centre of the picture, as shown. It is therefore evident that a close relationship exists between the balancing of weights in mechanics and the balancing of values in art.

23. The balance of values in black-and-white drawing is subject to laws similar to those governing the balance of actual weights. The centre of the paper on which the picture is drawn corresponds to the centre of gravity under the weights, and by a few experiments in the placing of unequal spots, so that they will balance within a rectangle, the operation of these laws of composition will be seen. In Fig. 14, the spot *a* is twice the size of the spot *b*, but is placed one-half the distance from the

centre that *b* is placed. Therefore, *a* and *b* are balanced as they would be in mechanics. In Fig. 15 the spot *a* is four times the size of the spot *b*, but these two are balanced because the distance *a c* is only one-fourth of the distance *b c*. Just as the difference in the weight of two bodies depends partly on their size and partly on the weight of the material composing them, so the difference in the importance of two spots is not determined

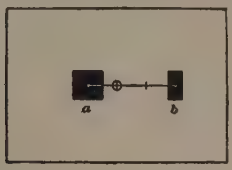


FIG. 14

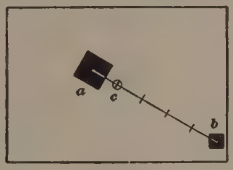


FIG. 15

solely on their relative sizes, but also on their relative light-and-shade values. This is as shown in Fig. 16, where the spot *a* is twice the size of spot *b*, but its light-and-shade value is only half as strong as *b*, and therefore these two are balanced when equidistant from the centre *c*, because *a*, being half as strong, is twice the size of *b*, and therefore equal in value. In Fig. 17 the lighter value *a* is balanced by the dark value *b*, although

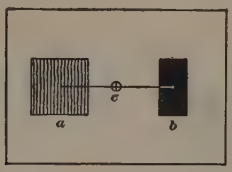


FIG. 16

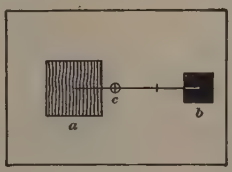


FIG. 17

the latter is but one-fourth the size of *a*. Being one-fourth the size and twice the strength in colour, it has half the value of *a* and balances with *a* when placed from *c* a distance twice as great as *a* is placed.

24. Balance in composition consists of the proper grouping of the masses of light and shade, so that the eye is directed toward a central point. In order to appreciate this, several

problems in the balancing of spots should be solved, working first with squares and rectangles which should be accurately calculated and measured. Irregular spots should then be taken ; and, finally, natural objects should be grouped in order to get their light-and-shade values properly balanced within a given rectangle. If, on looking at a drawing, it is felt that there is more weight, so to speak, on one side than on another, the balance can be restored by deepening the colour or shadow or by increasing its area. This principle of balance must be considered carefully in all work of the pen draughtsman. Study the work of prominent illustrators with these principles in mind and observe whether the values distribute themselves properly so that the eye is held to the centre of the drawing. Also, when walking through the country or town, study natural objects, such as groups of buildings or scenery, and make mental pictures of how they should be rendered in black and white. The benefit obtained from the practice of this habit is not realized until the artist is face to face with an actual problem, and he has a drawing to be rendered in front of him, when these mental pictures will come back to him and aid considerably in his work.

25. The best effects are obtained usually when a drawing has its principal dark spot brought into balance by a smaller dark spot combined with a proper amount of other values. It is not necessary that the centre of balance should be exactly in the centre of the picture. It is usually near the centre, however, and is only removed therefrom to produce some special purpose. In general pictoral composition the balancing of equal masses is not satisfactory, as it is likely to introduce an appearance of doubleness to the picture ; that is, the two equal masses will divide the interest instead of uniting it in one general effect. Therefore, the important mass or centre of attraction in the picture should be made most prominent, and the minor masses rendered in values that will properly balance it without competing with it in importance. In decorative composition, however, a symmetrical arrangement of one mass equally balancing the other mass is frequently employed and is one of the most useful elements in this line of work.

26. Rhythm, applied to composition, is an orderly movement from form to form, from line to line, or from value to value. The even gradation from black to white, as shown in Figs. 3 and 4, is a rhythm of values. It is an even progression that is smooth and satisfactory, giving a feeling of restfulness. In Fig. 18, the contrast between (*b*) and (*c*) is so much greater than between (*b*) and (*a*) that there is no rhythm.

FIG. 18

There is also no rhythm in Fig. 19, for the jump from (*a*) to (*b*) is greater than from (*b*) to (*c*); in other words, (*b*) is much lighter than (*a*), though (*c*) is not much lighter than (*b*). But there is a rhythm of values in Fig. 20, for (*a*), (*b*), and (*c*) progress evenly in tone from one to the other.

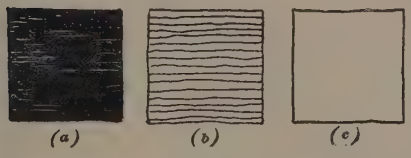


FIG. 19

27. Comparing the values in Figs. 18 to 20 with those in Fig. 4, it will be seen that the jump from (*b*) to (*c*), Fig. 18, is practically the same as the jump from (*b*) to (*e*), Fig. 4, while in Fig. 19 the jump from (*a*) to (*b*) is practically the same as the jump from (*a*) to (*d*), Fig. 4; but in Fig. 20, the values (*a*), (*b*), and (*c*) correspond to the values (*a*), (*c*), and (*e*), Fig. 4, and are therefore rhythmic. The use of the values in Fig. 20 will, as a rule, give a more satisfactory rendering of a drawing than the use of the unrelated values in Figs. 18 and 19, although there are occasions where these great contrasts may be required.

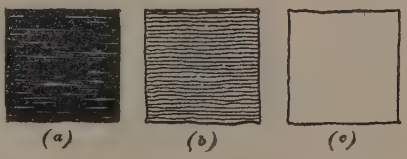


FIG. 20

28. Rhythm of Line.—Rhythm of line in pen drawing is an orderly movement or progression from line to line. For instance, observe, in Fig. 21 (*a*), how one line leads gracefully and evenly to another, and how the eye follows from one to the other without interruption or break; but in (*b*) the lines are broken and antagonistic, and give a feeling of unrest. The lines in (*a*) are

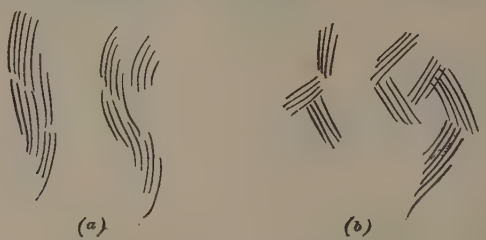


FIG. 21

rhythmic; the lines in (*b*) are not. There are occasions where the form of shading shown in (*b*) is necessary and useful, particularly where a rough, uneven surface is required, the very feeling of the antagonism and contrast of the lines producing the feeling of roughness of surface that is intended. As a rule, however, the form of rendering shown in (*a*) is more pleasing and more suitable.

29. Harmony. — **Harmony** in composition arises from a consistency in the character of the lines and tones. The term harmony is more frequently used in connection with colour work, but it may be used in pen rendering as well to signify the choice of lines that are used for the representation of different objects. In a successful drawing there is always a similarity in character in all the lines used. They may, and usually should, vary in strength and in lesser characteristics, but they should all have something in common.

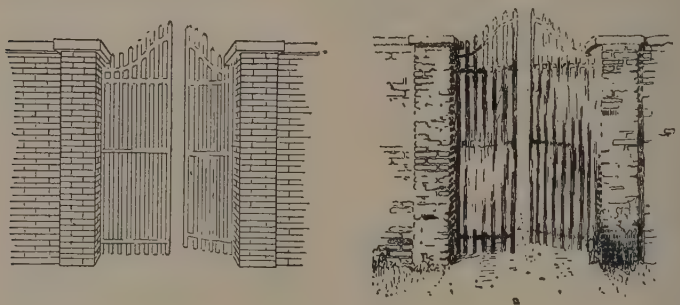
30. The tendency of the beginner is to use lines of varying and uncertain character in his drawing. This is to be expected at first and should cause him no discouragement, for harmony of line can only be achieved after much practice with the right principles constantly before the mind. The work of good pen

artists should be studied, not that it may be copied, but that the method of expression may be learnt. No two methods are exactly alike, and yet all illustrate the same principles. The artist's individual way, if properly worked up, will always be best suited to his tastes, and there is no more reason why he should imitate one man's way of working than he should imitate his way of walking or writing. No two men write exactly alike, and it seldom happens that one man tries to imitate another man's style of language or handwriting. After much practice, without giving much thought to the appearance of the writing so long as it is legible, a man falls into a system of his own which can be recognized by his friends or identified by a stranger. It is the same with drawing. Principles should be studied and not methods. One's own methods will soon take form and will give character to one's work. Nevertheless, it is a useful exercise occasionally to copy a drawing in facsimile.

TEXTURES

31. Definition.—An important element in the consideration of all drawing is the question of light and shade on the object, and the character of line with which it is rendered. One must be made to feel the material of which every part of the depicted object is composed the moment one looks on a drawing. A shingle roof must be rendered in such a manner that it expresses shingles, without drawing an individual shingle upon it. A brick wall should be specific of regularly coursed bricks, without any attempt to lay out those bricks in hard outlines. Heavy draperies should express themselves by the weight of their folds, and light draperies should show their *texture* by the method of their rendering. By **texture,** in rendering, is meant the expression of the particular quality that characterizes any material represented. It is a very broad term and is frequently used, as it is very essential to suggest in a satisfactory manner the difference in material of parts of a study. It is very important in illustrating that texture be shown, but it can be very easily overdone. It should be suggested rather than expressed.

32. A plain brick wall ruled off to show all the joints in the brickwork, as in Fig. 22 (*a*), would make a very monotonous and uninteresting drawing, inasmuch as in an illustration it is not the construction of the object but its pictorial value that is of importance. Properly rendered, the texture of a brick wall can be shown without an expression of more than a few bricks in its entire surface, as in Fig. 22 (*b*), and even at times without the direct indication of any bricks at all. On the other hand, much life can be given to an illustration by the careful rendering of these simple textures, as may be seen in the illustration by Herbert Railton, Fig. 48. The broad expanses of wall and



(*a*) (*b*)

FIG. 22

chimney, through which the timber construction occasionally shows, easily convey the impression of their plaster texture. The work below and in the neighbouring walls and chimney tells a story of coursed brickwork, and does not interfere in any way with the composition of the picture by giving too much importance to the elements of this architectural construction. This artist's drawings show his tendency to work up the details of texture rather more minutely than can be generally recommended, as much skill is required in order to prevent such close working from destroying the general interest in the composition.

33. In Fig. 23 is shown a portion of a drawing by H. Thomson, to an enlarged scale, which gives a good idea of this artist's

method of obtaining texture in his composition. The rendering is bold and free and gives a thoroughly true impression that the stonework it represents is old and worn. It will be seen that the mouldings and panels, of which the subject is composed, are obtained almost entirely by suggestion, great care being taken in

Fig. 23

depicting the shadows correctly. Another example of the rendering of materials is given in Fig. 24, where is shown a portion of a drawing by F. L. B. Griggs. The method adopted here is quite different from that in Fig. 23, as the individual portions of the composition are more definitely outlined; and,

FIG. 24

though the drawing is simply rendered in black and white, there is no mistaking the different materials of which the building is constructed. The woodwork of the gable and half-timbered work, with plaster filling, the stone head to the window underneath the gable, and the tiling on the roof are all clearly and unmistakably expressed, while the glass in the windows is particularly well rendered. Even in the rendering of the deep shadow cast from the gable on to the tiled roof the expression of tiling is not lost.

34. Importance of Texture in Composition.—It is very important that materials be indicated in a drawing by the quality and direction of the lines. A combination of lines used to represent timber can never be used to show bricks or stones. But there is no hard and fast rule for arriving at a distinctive treatment, as it is largely a question of individuality. The work of artists like Pennell, Fitton, and Gregg should be studied so that their methods of depicting different materials by varying the quality of their lines may be observed. It may truly be said that all lines and tones used by these artists are illustrated in Figs. 4 and 21 ; and that all the variety of style, appearance, technique, and composition that is found in their work is due entirely to their personality and individuality. D. A. Gregg, in Fig. 36, indicates the firm stonework in his tower by carefully placed values indicative of coursed masonry, with a suggestion here and there of a crumbling joint. Martin Rico secures the feeling of brilliant, warm Venetian sunshine in his pictures by using large masses of white contrasted with rather deep shadow, whereas Maxime Lalanne creates a similar impression by the subtle delicacy of the details in his sketches without expressing any deep shadows at all. In practising pen work, one should not judge the results of his efforts by the appearance or style of his own productions in comparison with those of some one else. His style will develop as he proceeds, and his work will become characteristic of himself as the work of the artists herein illustrated has become characteristic of each of them, but only after careful and painstaking study will this be accomplished.

COMMON ERRORS OF BEGINNERS

35. Fig. 25 illustrates some of the common faults of a beginner. It is the reproduction of a drawing made by a person who had not properly mastered his scale of values or his rhythm of line. It is not a bad drawing for a novice, as one can see that he has tried to obtain certain effects, but there is a lack of balance in the picture. The left side attracts the eye more than the right side by its two dark masses of nearly equal size, one formed by the trees *a*, *b* and

FIG. 25

the other by the door *c*, with the wall at the side, the roof over it, and the small mass of foliage over the roof. These details are so nearly of one value that they form practically a single dark spot in the left half of the picture. Two equal masses of black in a picture, even if equally balanced, are not desirable, as they divide the interest and have no unity of effect. In this case,

these two equal masses are doubly disagreeable, as they are not balanced about the centre.

36. The values in this drawing are uncertain ; that is, they lack purity and definiteness as well as rhythm. For example, the roofs *i*, *g* are, in general effect, of about the middle value, and are spotted with darker and lighter values, but this spotting adds no interest, gives no idea of its material or texture, and is in itself ugly. The walls *d* and *e* contain lines so light and weak and so hesitatingly drawn that they do not produce any effect whatever of colour or of texture. They do not tell whether the wall is of wood, stone, or plaster, or that any shadow falls on it, and might better have been left out entirely. At least a part of the wall *d* should have been left white, while another part should have contained a few suggestions of stonework or broken plaster in order to give an idea of its material. If it is in shadow, a tint should be seen ; but instead of that, where values should be given simply scratches are shown. The same may be said of the lines *f* introduced into the foreground and those in the sky at *h*. These lines neither tell a story nor represent value ; they are simply meaningless. It would have been better to have left the ground and sky plain, or, if a value were needed, it should have been definitely rendered and represented by lines of the proper kind.

37. The drawing is so lacking in definite values that there is no possibility of a rhythmic movement from dark to light. The lines are not properly related to one another and there is a harsh, disagreeable effect instead of a soft, pleasing one. The lines themselves are bad throughout. Even in the enclosing line of the drawing there is a lack of firmness and evenness of stroke. Study any individual line, and it is seen to vary in weight and strength, and its direction is uncertain ; this is in itself a fault. Whatever may be the width of a line, that width should, as a rule, prevail throughout its entire length. It should begin firmly and end firmly, and not taper off to a point as these lines do. Another fault in the use of lines is seen in the shadow within the door at *c*. A few broad, rich strokes would have given this point its proper tone and value. The results with this method are smudgy and muddy, in a similar manner as on the roof at *g*.

38. There is a lack of rhythm in the lines between *a* and *b*. The horizontal lines at *a* have no relation whatever to the curved scratchy lines above at *b*, and neither of them expresses texture. In fact, none of the lines in the drawing makes any attempt to express texture. The strokes at *b* fail to give anything like a leafy effect; compare these with the drawings of trees by Pennell in Fig. 49 or by Gregg in Fig. 5. The chimney does not tell us whether it is of brick, stone, or plaster. There is nothing anywhere to indicate material; compare it with the representation of brick by Goodhue, in Fig. 41, and Fitton, in Fig. 53. The window treatment is monotonous; the lines are lacking in the lightness of touch that would suggest glass. The window as a whole is too dark; it simply forms an isolated spot in the drawing. The lines in the foreground are without any meaning whatsoever, although there has been an evident attempt to express the idea of grass with a few short, vertical strokes. Observe the treatment of the foregrounds in Figs. 38 and 40; the lines are few, but they clearly tell a definite story of earth, stones, grass, and weeds.

DRAWING PLATE, TITLE: PRELIMINARY PEN PRACTICE

39. The work on this plate is to be done and sent in for criticism. On a sheet of Bristol-board, 18 inches by 14 inches, draw a border line enclosing a space 17 inches by 13 inches, and divide the rectangle so formed through the middle by a line *a a*, $8\frac{1}{2}$ inches from the end border lines. The line *b b* is situated $\frac{1}{2}$ inch to the left of *a a*, *c c* is $6\frac{1}{4}$ inches above the lower border line, and *d d* is $\frac{3}{4}$ inch below *c c*. These lines will divide the drawing plate into four sections, each one containing a number of figures. Vertical lines *e e* and *f f* should be drawn, also a horizontal line from *e* to *f* $\frac{3}{4}$ inch above the lower border line.

40. Figs. **1*** to **3** are contained in three rectangles, $3\frac{1}{2}$ inches by $2\frac{1}{2}$ inches, nearly, which have a line $\frac{3}{4}$ inch below the upper

* To distinguish the figures on the plates from those in the text, the figure numbers on the former are printed in heavier type, as here indicated.

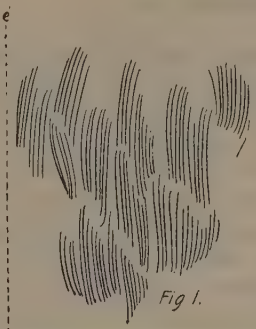


Fig 1.

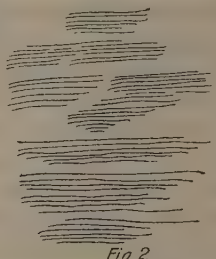


Fig.2.

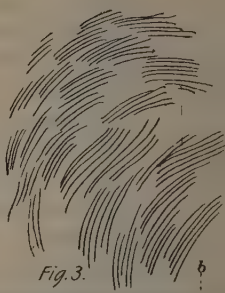


Fig.3.

a

b

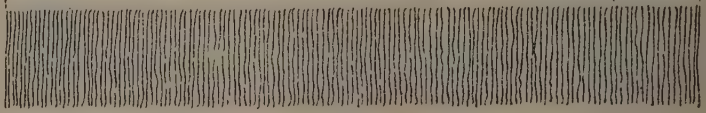
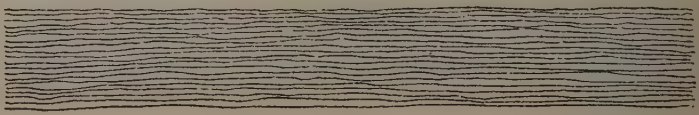


Fig.4.



c

Fig.5.

d

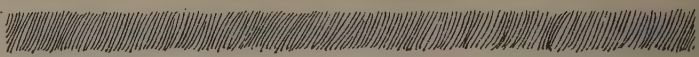


Fig.13.

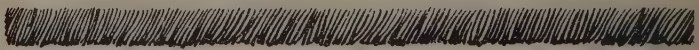
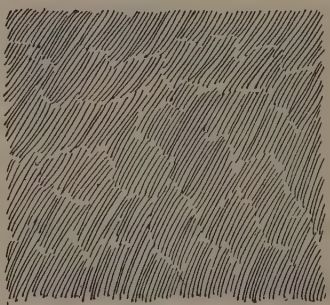


Fig.14.



e

Fig.18.

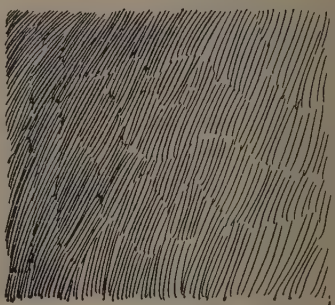


Fig.19.

b

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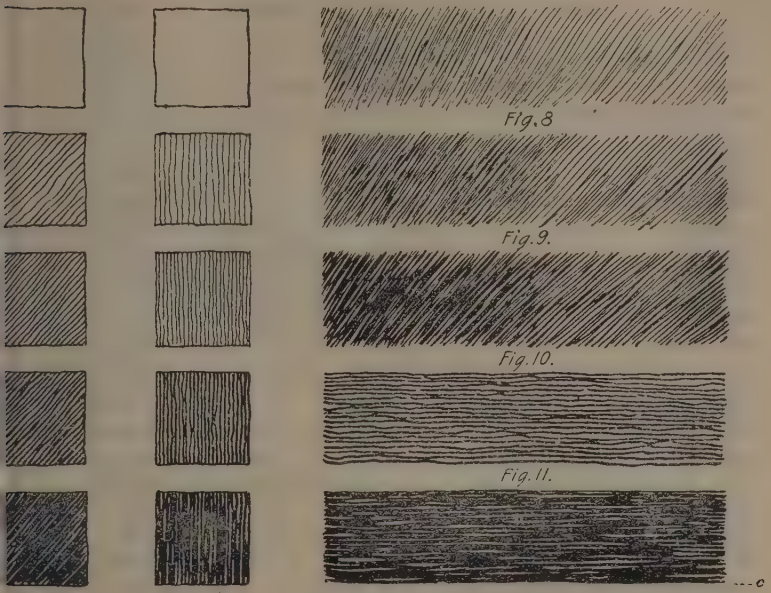

Fig. 6. Fig. 7. Fig. 8. Fig. 9. Fig. 10. Fig. 11. Fig. 12.

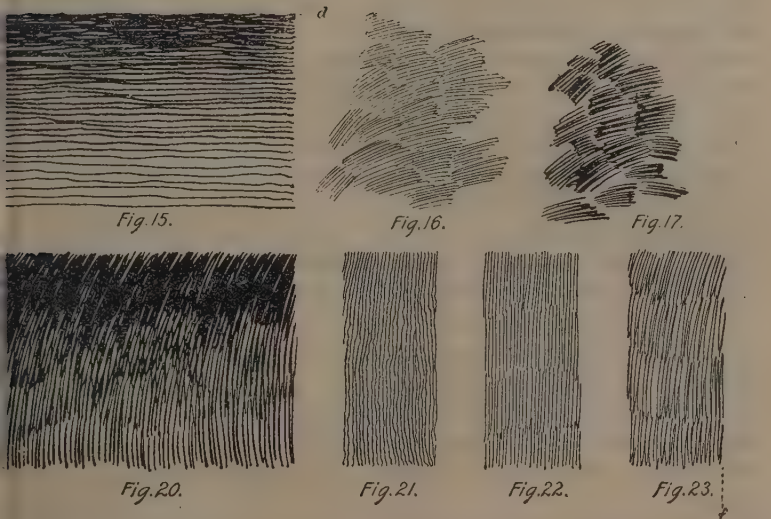

Fig. 15. Fig. 16. Fig. 17. Fig. 20. Fig. 21. Fig. 22. Fig. 23.

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border line as their upper limits. Immediately below them Fig. **4** is drawn extending from the line *e e* to the line *b b*, 1 inch in width. Fig. **5** is drawn within a rectangle 1 inch in width and $\frac{1}{2}$ inch below Fig. **4**. Fig. **13** is $\frac{3}{4}$ inch below Fig. **5** and $\frac{3}{8}$ inch in width. Fig. **14** is $\frac{1}{2}$ inch below Fig. **13** and $\frac{3}{8}$ inch in width. Figs. **18** and **19** are $\frac{1}{2}$ inch below Fig. **14** and are $3\frac{1}{4}$ inches by 3 inches. Figs. **6** and **7** consist of a series of squares, each being $\frac{1}{4}$ inch below the other, with $\frac{3}{4}$ inch between the sets. There is also $\frac{3}{4}$ inch between Fig. **7** and Fig. **12**, and the details or stripes of Figs. **8** to **12** are 1 inch in width and $\frac{1}{4}$ inch apart. Fig. **15** is $3\frac{1}{4}$ inches by 2 inches and Fig. **20** $3\frac{1}{4}$ inches by $2\frac{1}{4}$ inches, with a $\frac{1}{2}$-inch space between them. Figs. **21** to **23** are 1 inch wide and $\frac{1}{2}$ inch apart. Two spaces, each about 2 inches high, between these last three figures and Fig. **12** are then set apart for Figs. **16** and **17**. If these instructions are followed, no difficulty should be experienced in commencing pen work.

41. Each of the figures on this plate should be practised repeatedly before it is drawn on the drawing plate. But, in practising, it is not necessary to make a duplicate of such exercises as Figs. **1** to **3, 16,** and **17,** but simply to render lines in that style, according to the directions here given. All the subdivisions of the plate should be made with a T square and set-square, and should be drawn in pencil. After the plate is finished the pencil lines should be erased and the drawing plate sent to the Schools for criticism. All of the ink work on this plate is done directly, without any pencil foundation, except Figs. **16** and **17,** in which the outlines have been previously drawn in pencil. Generally speaking, the lines of these different exercises are drawn at different rates of speed. All vertical, horizontal, and diagonal lines, which are practically straight lines, are drawn carefully, deliberately, and evenly. They start abruptly and end suddenly, and should not taper off to a point where they finish.

42. Fig. **5** is made up of lines very slowly and carefully drawn. It should take about 10 seconds to complete one of the horizontal lines of which Fig. **5** is composed. In Fig. **8** the lines are drawn more rapidly, one following the other without any general attempt at exact parallelism but simply to secure a tint. Notice the

difference in quality owing to these two conditions. Fig. **1** consists of groups of lines that are practically vertical and parallel. They are drawn with a moderately brisk movement, about half-way in speed between Figs. **5** and **8**. Fig. **2** consists of a series of horizontal lines. In this work practice is imperative. It is more difficult than Fig. **1**, and the lines must be more slowly executed.

43. Fig. **3** is more difficult than either of the preceding, owing to the change of direction of the different groups of lines. Some of the lines are drawn from right to left, and others from left to right. The horizontal lines in Fig. **2** are drawn from left to right, and those in Fig. **3** more nearly approaching the horizontal should also be drawn in that direction. Notice that the principle of rhythm has been carefully observed in the arrangement of these lines, and preserve this quality in your drawing. See that each group of lines follows the preceding one naturally and is not butted up against it at an obtuse angle. Whichever figure is drawn, the effort should be to keep the lines an even thickness, using a definite amount of pressure throughout the entire stroke. In each of these groups the lengths of the lines vary, some of them being simple curves, some reverse curves, and some straight lines. This slight curvature of shade lines, varying under different conditions, gives a variety and grace to the work. In rendering this plate, do not attempt to copy any particular figure, but simply produce a series of tints after the manner they have been produced here, using the same direction of line and rendering it in a similar manner.

44. Fig. **4** is an even value, made up of slowly drawn lines. The strength of the lines is uniform throughout, and the spaces between them, though varying slightly in some places, are practically the same, so that it produces the effect of an even shade. Many of the lines are broken, but care has been exercised to see that several breaks do not occur together, so as to produce the effect of a white line. Fig. **5** differs from Fig. **4** only in the direction of the lines. The pen is turned, in drawing from left to right, in order that both of the nibs or points may rest evenly on the paper. The lines should be broken from time to time

as the work proceeds, and an effort made to avoid an even waviness.

45. Figs. **6** and **7** should be drawn according to preceding instructions. Each of these represents a scale of five values; draw the darkest value first. In both instances use considerable pressure on the pen and execute each stroke slowly. Place them so close together that they run into one another, except at a few points where the white shows through, but be careful not to make any blots. Considerable ink runs from the pen to the paper in making this dark value, and it is sometimes necessary to take up some of it with a piece of blotting paper. In so doing, let only the edge of the blotting paper touch the top of the ink; do not press the blotting paper to the drawing-paper or a blot and a pale shade of ink will result. After making this darkest value, wait for it to dry and then put in the middle value, using a moderate pressure and noting carefully the space between the lines in order to preserve uniformity. Follow the middle tint by the dark grey below it. The stroke for the dark grey is of about the same weight as that used for the darkest tint, but the lines are spaced farther apart. The lighter grey tint is prepared with lighter lines than those of the middle tint, and spaced farther apart. Sometimes the ink dries rather slowly; do not try to hurry by heating it, or by touching it with a blotter except as before stated. To avoid smearing the drawing when it is wet, lay your board aside and practise the next exercise on a piece of waste paper. In this way no time will be lost, and the work will proceed without interruption.

46. Figs. **8** to **10** illustrate a more rapid use of the pen. To acquire this rapid stroke and at the same time to keep the lines uniform in spacing and weight requires considerable practice, but the freedom acquired by such practice is of the greatest service. To all appearance the lines of these figures are careless, but they are "carefully" careless; that is, their careless appearance is a matter of study and does not arise from carelessness in execution. These exercises differ from those that precede, inasmuch as some of the lines cross one another and produce at these points darker values. Care should be

taken, however, that blots do not occur in running a new line over one that is still wet with a pen that is overcharged with ink.

In Fig. **8**, the long rectangle should be tinted evenly with a series of lines, such as appear at its right end. Most of the lines are not long enough to extend across the rectangle, so that two sets are necessary to cover the space. When the second series of strokes is drawn, no attempt should be made to have them exactly join at the ends of the first ones. It is better to let them begin between the lower ends of the first set. When the space is covered, go over the left half to darken it to the value of central grey by means of strokes of the same weight and kind. These lines make a very slight angle with the first set. In Fig. **9**, the first value made is middle grey, with a series of fine strokes somewhat heavier than in Fig. **8** and with smaller spaces between them. The left half of the space is then darkened by lines of the same weight, but inclined at a slightly different angle. Fig. **10** is executed in a manner similar to Figs. **8** and **9**, with the exception that greater pressure is used. The right half should start with a dark grey, and the left half should grade up to the darkest value of the scale. Hereafter this tint will be called black ; but by this is not meant a solid black but a line-tinted black, such as is shown at the bottom of Figs. **6** and **7**.

47. Fig. **11** is composed of slowly and carefully drawn lines similar to Fig. **5**, from which it differs only in value. The width of the line is obtained by an even pressure. The lines should be broken wherever necessary, care being taken that two breaks do not occur near the same place so as to form a white line across the figure. Always lift the pen from the paper when the line has been drawn as far as an unconstrained movement of the fingers will permit. This should be done abruptly so that the line will not taper off to a point, as is otherwise likely to happen. Fig. **12** is similar to Fig. **11**, except that it is darker and corresponds with the last tint of the colour scale at the bottom of Figs. **6** and **7**. The lines are drawn close together, so that they occasionally blend and produce a ropy effect. This method of rendering is frequently used in the roofs of buildings.

48. Figs. **13** and **14** are drawn with lines of moderate rapidity and differ only in tone. Fig. **13** is equal to middle grey, while Fig. **14** is dark grey, becoming black at the bottom where extra pressure is used, causing the lines to unite. Observe the slight curvature of the lines, which is much less than that in Fig. **1.** The slight changes in the direction of this curve help to prevent the mechanical appearance that would result if the lines were all exactly parallel. This treatment of lines is frequently employed in the rendering of shadows under the eaves of houses.

Fig. **15** is a graded exercise working from black to light grey and executed in the same manner as explained in connection with Figs. **5, 11,** and **12.** Fig. **16** introduces a new quality of line. The strokes are made from left to right rapidly and close together. They are very short, of different lengths, and much finer than any that have yet been drawn. The changes of direction and upward curvature give them character and variety; such lines are useful in representing masses of foliage or trees. Fig. **17** is identical in character with Fig. **16,** except that some of the lines are drawn from right to left and are accented on the ends of the strokes. They are also several tones darker than in Fig. **16,** greater pressure being used.

49. Fig. **18** shows a method of covering a large surface with a middle-grey value. The lines are like those used in Fig. **16,** but are drawn from the top down; they do not touch at the ends. Fig. **19** shows a tint graded from dark grey on the left to light grey on the right. This change in value is produced by a diminution in pressure and an increase in the spacing of the lines. Fig. **20** is a problem similar to that in Fig. **10,** except that the lines more nearly approach the perpendicular. The gradation, however, is from black at the top to grey at the bottom, and is produced by drawing two sets of lines, one forming an even grey, and the other crossing it at an angle and forming black.

50. Figs. **21** to **23** are examples of surface shading with vertical lines. In Fig. **21** the lines are drawn carefully and slowly and are slightly curved. If these lines are crinkly or wavy, as shown, they diminish the mechanical effect; but this

quality of line should not be studied or sought for, it should come merely from the unsteadiness of the hand when moving slowly. In Fig. **22** the tint is made up of short lines with joined ends. These lines are drawn rapidly in order to cover the surface freely. In Fig. **23** is illustrated a very broad and free way of covering a surface. It might be called *scribbling*, as the lines are drawn so rapidly that sometimes the upward stroke of the pen makes a mark on the paper. This is not to be recommended for general drawing, as it is likely to produce slovenly work, but it is useful when a sketch must be made in a hurry and changing values recorded while they last.

51. After each of these figures has been drawn, rule a line $\frac{1}{4}$ inch below the upper border line and another $\frac{1}{4}$ inch below. Carefully pencil in the outlines of the title between these lines, but it should be inked in freehand. The date should then be placed in the lower left-hand corner, and the name and class letters and number in the lower right-hand corner, after which the border line should be inked in freehand and the plate cleaned up and forwarded for criticism.

DRAWING PLATE, TITLE: INTRODUCTORY EXERCISES

52. This plate makes practical use of some of the tones and values practised on the preceding plate. The objects selected are so simple in character that besides being copied from the drawing plate, their duplicates, or objects similar to them, should be obtained and rendered from nature. It will be observed that on the different objects rendered the lines are drawn in different directions. Different tones or values are expressed to indicate differences of material. The study of these values in the representation of texture is of vast importance. Before commencing the final rendering on the outline plate, the figures should be practised several times on separate sheets of paper in order to gain facility in the handling. The inking in of the outline plate should not be begun until sufficient facility has been attained.

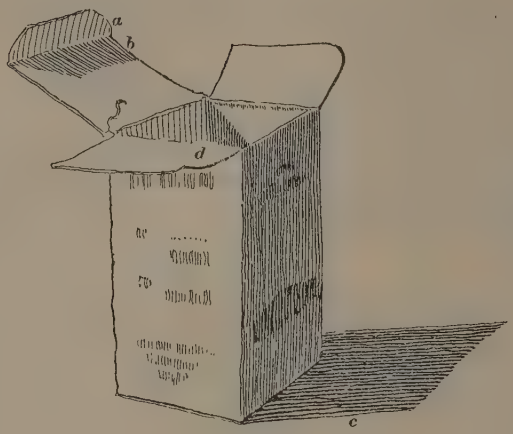
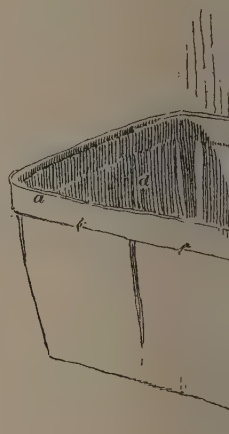


Fig. 1.



A

C

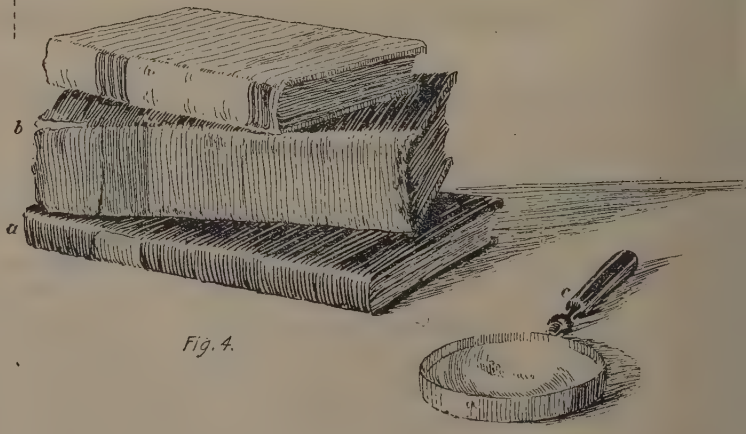


Fig. 4.

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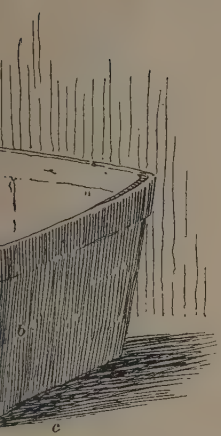

Fig. 3.

D

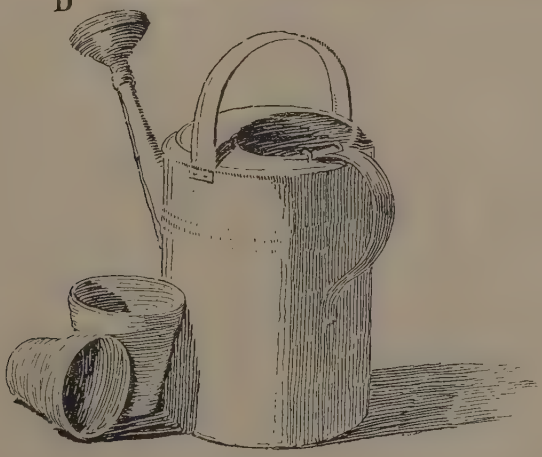

Fig. 5.

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53. If, when rendering the outline plate, a mistake is made, or inferior rendering is executed, a new drawing plate outline may be made by tracing the outline plate on a piece of tracing paper, great care being taken that all the outlines on the plate are carefully followed. When the tracing is completed, the tracing paper with the outlines of the plate upon it should be laid face downwards on a sheet of white paper. With a very soft pencil, go carefully over, on the back of the tracing paper, all the lines of the tracing, and, when this is done, lay the tracing over the sheet of paper on which the rendering is to be done, care being taken to have the side with the original tracing on uppermost. Now go over the tracing again with a fairly hard and well-pointed pencil, when it will be found, on the removal of the tracing paper, that a complete outline of the composition on the original outline sheet will appear on the paper on which the final rendered drawing is to be made. Care must be taken not to rub this outline, as it will easily smudge and spoil the paper.

54. Fig. **1** is a paper box presenting simple plain surfaces. The handling is direct and significant. Vertical surfaces are emphasized by a tint of vertical lines ; the oblique surface *a* is rendered in oblique lines, and the shadow *b* is rendered in lines conforming to the slant of the surface on which it falls. The shadow *c* of the box is made up of lines that take their direction from the direction of the light that casts the shadow. Observe that in this simple rendering three values have been used besides white ; namely, light grey, middle grey, and dark grey. The light grey is used at the back and inside of the box and on the flap at *a* ; the middle grey is used in the shadow of the flap at *b* and the inside of the box, and the front of the outside ; and the dark grey, as the cast shadow *c* of the box. The cast shadow here, as always, is darker than the shaded side of the object, which is affected by reflected light. None of the lines in this rendering are drawn rapidly. They are applications of the exercises shown on the previous plate, Figs. **4, 6,** and **7.** Notice that the lettering on the box is expressed by values only, no attempt being made to make it readable. Observe, also,

that in many places the outline of the box is omitted, as the shadow is sufficient to mark the boundary of the surface; this is particularly observable at *d*.

55. In Fig. **2** the values are rendered by more rapidly drawn lines. This gives life to the drawing and emphasizes the lightness of the material; in other words, gives it character. The shaded surfaces *b*, *d* are not expressed by one series of lines like those used in Fig. **1**, but are made up of several series of short lines. The rim about the top of the box is expressed in the shadow *d* by a slight space between the two series of lines that make up the shadow. In the shadow *b*, the rim is expressed partially by the same means and partially by touches added to indicate the lower edge. The introduction of cross-hatchings in the shadow at *c* is a simple method of giving the gradation that shadows possess; namely, of being darkest near the object that casts the shadow, though sometimes, through the effect of contrast and reflected light, they are darkest at the outer edge. The light sketchy treatment of the details, and the use of the lightest value in the background, are points to be carefully noted. The background is rendered in such a manner as to die off at the edges irregularly and in the most unobtrusive manner. The direction of line in the rendered value follows the same laws as in Fig. **1**, which should be borne in mind when rendering. Pains should be taken to indicate the thickness of the basket wherever it appears, as this is another detail that gives the character of the material it is made of.

56. Fig. **3** is a more difficult problem, in that it exhibits curved surfaces; this involves the necessity of changing the direction of the line on different parts of the surface. The original of the object here shown is a clay vase, rather crude in form and of a character that did not demand a treatment that would suggest smoothness or finish. The lines should be drawn at a moderate rate of speed, but with care and attention. They are short and form groups that follow each other about the surface. The darker tones at *a*, *b*, and *c* are indicated by heavier lines slightly cross-hatched. At *d* and on the body of the vase a lighter value is introduced as the shade meets the light. This

adds to the effect of roundness. This study will require careful practice, as the rendering of globular and cylindrical surfaces is not easy.

57. Fig. 4 shows a pile of old books; books always make interesting subjects for drawing. In making a group to sketch from, a variety in size and thickness should be sought. In this illustration, not only is the appearance of old books well carried out, but the textures of the different covers are clearly indicated. In placing these books, their relative sizes have been carefully considered. The largest is naturally placed at the bottom, and the angles at which one is placed on the other differ sufficiently to give the impression that they have been carelessly laid down after reading. The reading glass gives a touch of interest and suggests that perhaps the books have been read by an elderly person. These details are of importance; they convey an idea of something beyond the illustration and help the picture to tell a story.

58. The values in this study range from white to black; the direction of the lines corresponds to the direction of the surfaces. The lines used in rendering the books are all slowly drawn. The slow and irregular line serves very well in the expression of the warped and uneven old covers and the edges of the leaves. In the reading glass a more regular touch is needed to give the effect of smoothness to the glass and to the metal rim and ebony handle. The lines are more crisp and decisive than those on the books, and indicate the difference in the texture of the material. Note how the light edges on the back of the books *a*, *b* are shown by a break between the series of lines that render the backs and tops. A similar treatment occurs in the handle of the reading glass at *c*. In the back of the book *b* the addition of lines drawn between the first series darkens the value at the right places to express the modelling. The shadows, both of the books and of the glass, are drawn briskly with light, rapid lines. Observe that, while the leaves on the ends of the books are indicated by a series of wavy, parallel lines, the thickness of the covers is expressed by a series of short, vertical lines in the direction of that thickness.

59. Examine this drawing carefully and observe that a hard outline is not introduced at any point where it is unnecessary. The little, uppermost book is outlined against the one below it by the stopping of the deep tone that indicates the cover of the latter, and the back of the second book is profiled against the cover of the bottom book by the meeting of the tones rather than by a hard line. The breadth of this study and the completeness of its effect show the advantage of avoiding fine lines, except where necessary to express smooth surfaces.

60. Fig. 5 is a group from the garden, consisting of curved surfaces rendered with carefully drawn lines characteristic of the surfaces they express. There are no deep tones on either the water-pot or the flower-pots. Observe, however, that the curved handle of the water-pot is shaded with lines that follow its curve, and that the sides are rendered with vertical lines carefully and evenly drawn. In the shade these lines stop just below the top to indicate the rim, or ring, that is turned about it, while a slight shading under this ring defines it in the high light. The inside of the water-pot is rendered with a darker tone, inasmuch as it is naturally much shielded from the light. The flower pots are simply rendered with lines, parallel to their tops, rapidly and crudely drawn in harmony with the crude material of which they are made. After each of these figures has been drawn, the date should be placed in the lower left-hand corner, and the name and class letters and number in the lower right-hand corner, after which the border line should be inked in freehand and the plate cleaned up and forwarded for criticism.

All the plates should be trimmed to a uniform size of 18 inches by 14 inches irrespective of the original size of the sheet.

DRAWING PLATE, TITLE: DETAILS AND ACCESSORIES

61. This plate contains a series of what might be called practical problems. Every element on it is likely at some time to become an element in the drawing or rendering of some illustration or picture. No difficulty should be experienced in following

DETAILS AND

Fig. 1.

Fig. 2.

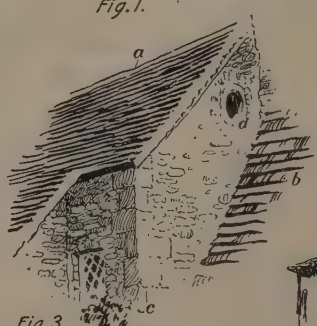

Fig. 3.

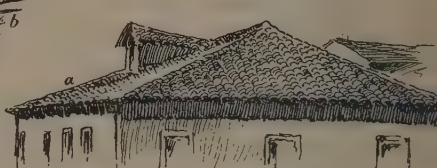

Fig. 4.

Fig 12

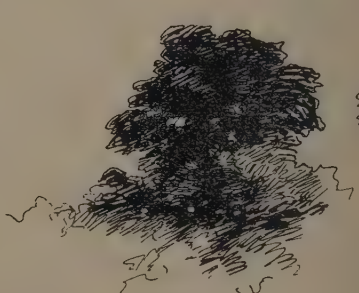

Fig. 13.

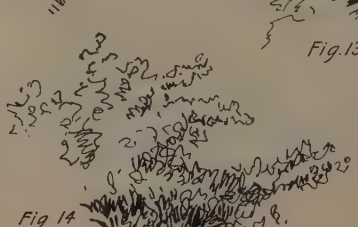

Fig 14

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CCESSORIES

Fig. 5.

Fig. 6.

Fig. 10.

Fig. 7.

Fig. 8.

Fig. 9.

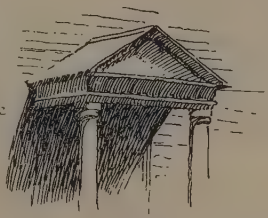
Fig. 11.

Fig. 16.

Fig. 17.

Fig. 18.

Fig. 19

Fig. 20.

Fig. 21

Fig. 22.

Fig. 23.

Fig. 24.

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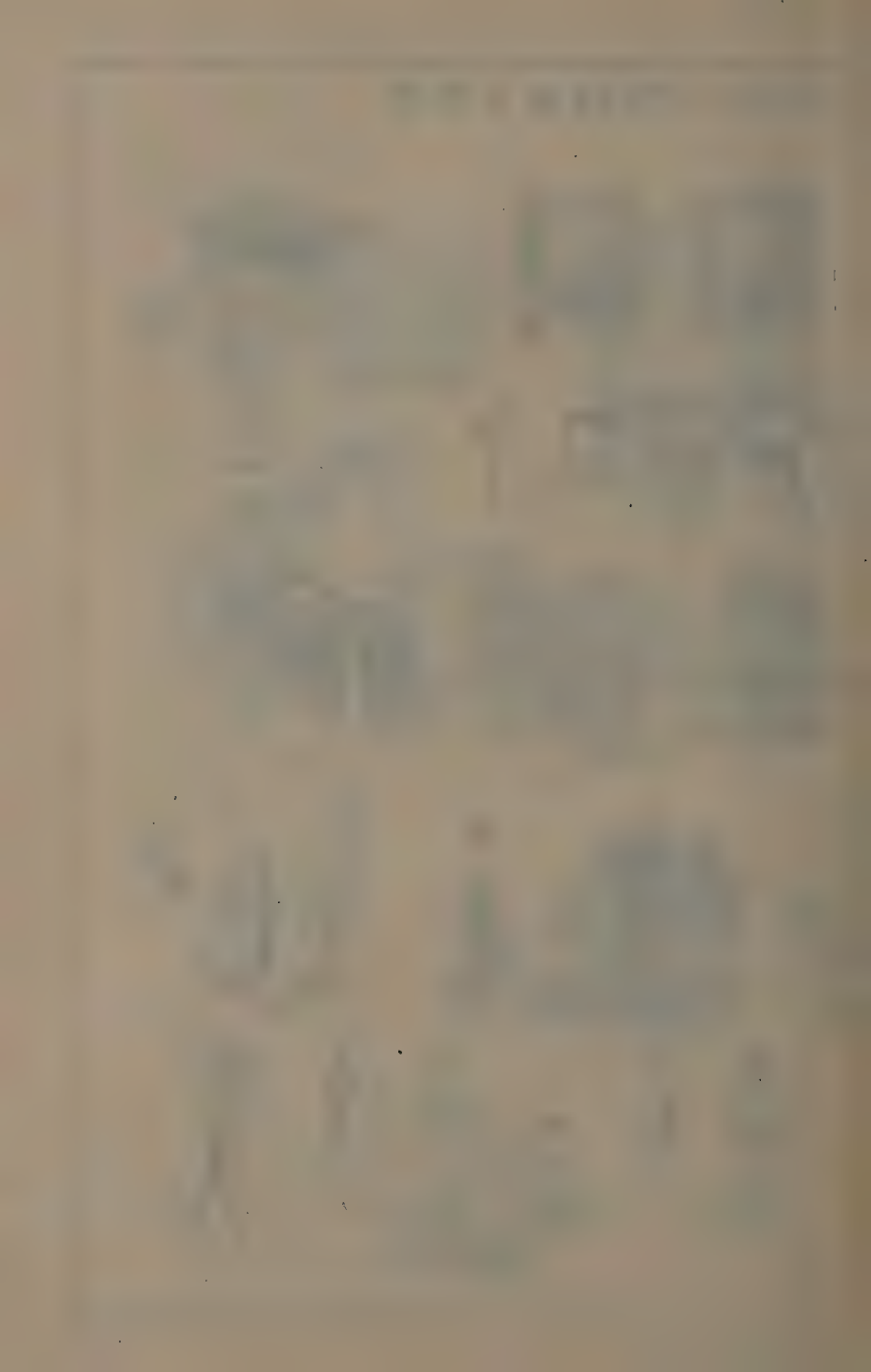


the instructions and presenting a perfectly satisfactory drawing. Each surface should be carefully studied in order that the values of the different textures may be properly rendered. For the purpose of practice, the figures on this plate should be carefully set out, or traced, and transferred, according to the outlines on the outline sheet, and rendered on a separate sheet, before commencing the rendering of the finished plate on the outline sheet. Although many parts of the finished drawing appear freely and carelessly rendered, the original pencil sketch is very carefully outlined in all its detail before the rendering is commenced. By this means the draughtsman always has a definite position for his lines, and each line can be made to express a separate detail. A drawing may look sketchy and free when the pencil lines are erased, but it can never appear satisfactorily so unless the pencil sketch has been carefully executed. The outline drawings accompanying this plate show how careful one must be in making the preparatory sketch. At the same time, the finished renderings on the drawing plate show how free the results from these careful preliminaries can be made to appear.

62. Do not make the mistake that many beginners do, that freedom, or sketchiness, in rendering a drawing implies that it was not carefully drawn in the beginning. The pencil work of an original sketch must be executed with the utmost care to warrant freedom in the rendering. While it is advisable to use in pen work as little outline as possible, it is all the more necessary that the outline shall be clear and definite in the pencil drawing in order to show just where to put the shadows that are to express it in the rendering. For practice, it will be best not to sketch in pencil on a separate sheet more than two or three of the figures on this sheet at one time, before an attempt is made to render the finished drawing.

63. Types of Roofs.—The first four figures on this plate are representations of roof textures, and care must be exercised not to overdo the rendering, or the drawing will lose the very characteristic that should be obtained; namely, the suggestion of the material. This depends as much on the way the pen is handled as on the kind of line that is drawn. Figs. **1** to **3** show

roofs of old cottages, but Fig. 4 is a new tiled roof. Study the rendering of such details as are illustrated in this plate, and then turn to the works by well-known artists, illustrated hereafter. It will be found that in every case the treatments vary, the individuality of the artists standing out clearly.

In Fig. **1,** the roofing material is a red tile, and is indicated in a general way by making the value of the roof tone a light grey. The age of the house is shown by the wavering of the lines that show the courses of the tiling. That some of the tiles have loosened, and others become dislocated entirely or discoloured by moss, is suggested by patches of deeper shade at irregular intervals. The overlapping of the tile courses is indicated by the character of the outline *c*. Compare with the roof lines the lighter lines used to indicate the weather boards on the building at the left side *b*. Notice how carefully, and yet sketchily, the distant ends of the weather boards are touched in to indicate that one board laps over another. Note that the lines of these boards are not carried entirely across the house, yet they convey to the observer a certainty that the material continues in the same manner where the paper is left untouched. Diminishing this value on the end of the building to a dead white where the roof overhangs greatly helps the general effect of the drawing.

64. The shadow *d* of the overhanging roof is drawn with a series of brisk lines, slightly accented at the bottom in order to express the abruptness with which the shadow stops and by the contrast, to give the feeling of sunlight. The direction of these lines suggests the direction in which the sunlight falls. Care must be exercised to keep this shadow in proper contrast with the roof above it. The value of the shadow diminishes as it becomes more distant ; this increases the effect of perspective. The dark part of the shadow under the darkest part of the roof is brought into strong contrast with the side of the house that is left white. The greatest contrasts are those at the angle of the house that is nearest to us and gives an appearance of recession in the distance. To indicate all the lines of the windows would not only be practically impossible, but decidedly uninteresting.

The details have simply been suggested, and the shadow that would naturally exist within the entire window on the end of the house has been limited to the upper side to prevent the introduction of a black spot in this light surface, which would materially affect the composition.

65. In Figs. **5** to **9** a more detailed rendering of windows is given, because in these the entire drawing consists in the representation of a window, whereas in Fig. **1** the window is only a portion of the whole building. In Figs. **5** to **9**, the drawing of the shadows is the principal means of bringing out the forms ; but in Fig. **1**, less shadow was required, and the introduction of shadows indicating an open sash and sash bars gives all the effect that is necessary. At *e*, Fig. **1**, a small mass of foliage without detail is introduced simply to give balance to the drawing and offset the dark masses at the right-hand side. The texture of this foliage is such that there is no doubt whatever as to its material, and it is rendered with a series of lines similar to Figs. **16** and **17** on the plate entitled Preliminary Pen Practice. In drawing foliage, the general character of the edges, or outline, should claim the first attention ; the next aim should be to get the value in tone by means of free, loose strokes, which in a general way should follow the direction of the leaf masses. Note throughout all these drawings how the lines are occasionally broken in order to give the effect of light and transparency.

66. The thatched roof in Fig. **2** presents an entirely different problem. Thatch is a fascinating texture to indicate and is well suited to the pen. The left side is in shadow, and is therefore covered with a light-grey value of short lines broken to show the different layers of straw. The right side is in full light, and is therefore left white with only sufficient shading to indicate that this, too, is thatched. These irregular indications also suggest the unevenness of the surface. The character of the lines used in the rendering of this roof is radically different from that in the tile roof. The rather fine and loosely drawn lines admirably suggest the straw in the thatch. On the shadow side *a* of the roof, the overlapping courses of straw are indicated by the overlapping and accented ends of the lines.

67. The small roof *b* has a tile texture, while the chimney, being built partly of brick and partly of stone, introduces still another texture. On the light side little detail is attempted, only occasional touches being given to indicate the irregular forms of which it is composed. On the shade side, however, considerable attention is given to the individual bricks. While, as has been said, the drawing of individual bricks is not necessary to indicate a brick wall, still the dark tone on the shadow side of the chimney and wall may be rendered quite as well by a series of partially rectangular forms as by a series of long straight lines. These forms therefore serve a double purpose: that of giving texture to the surface, and that of representing it in its proper tone. The principles of building construction must be observed in the rendering, and the joints between the bricks must break alternately. In good practice, no brick joints come directly over those immediately below.

68. At *c*, the chimney is clearly shown to be of small stones; this is indicated by the rounded edges and irregular outlines. At *d*, the material is plaster, shown simply as a flat value between the vertical and horizontal lines of the framing. The lines forming the shadow of the eaves on the tile roof conform in direction to the slope of the roof, while those at *e* on the vertical side of the house are vertical. What was said in connection with the foliage of Fig. **1** applies equally well to the rendering of the small bit of vine at the right of Fig. **2**. This foliage is of no importance, except to balance the picture by introducing a small dark value in a large area of light. It prevents the picture appearing one-sided. A study of Fig. 7 in the text will show how well the artist has interpreted the texture of tiled and thatched roofs, as also the texture of brickwork in the chimney.

69. In Fig. **3** is a tile roof that differs in treatment from Fig. **1** and gives the effect of a nearer view. The heavy lines used on the roofs *a*, *b* are made with slow strokes of considerable pressure. They present an effect of shadows, of courses of tiles, which, taken together, give an agreeable dark value to the roof. Careful attention should be given the treatment of the stone

blocks at the corner *c*, and also to the suggestion of the wedge-shaped stones round the window *d*. None of these details is indicated sharply and clearly, yet an improper rendering of the direction of these lines, slight though it may be, would be a fault in the drawing. One of the greatest difficulties of successful pen rendering is to know where to stop in the rendering of the characteristic details, and at the same time to give careful and sympathetic treatment to them. In giving value to the stone-work in shadow, the texture of the stone has been rendered by free, curving lines, and at the left of the rectangular window by a few irregular dots; but this method should be used sparingly. The beginner should study magazine illustrations by well-known artists and observe how skilfully this dotting is sometimes used. It is introduced here simply to prevent the wall beyond the rectangular window from being an absolute white like the value on the end of the window. This window has lozenge-shaped panes; these are rendered black, the lead work being left white. In the pencil sketch prepared for this drawing, the sash bars must be drawn in, but the pen work concerns itself only with the values; the pencil lines are ignored except as limitations to the black panes.

70. The outline sketch of Fig. **4** shows only the lines of the tiles, but the pen work by semicircular strokes will suggest the individual tiles. The introduction of these semicircular strokes is in conformity with the rendering of the flower-pots in the plate entitled Introductory Exercises; the line of the shading follows as closely as possible the general outline of the object shaded. On the left side of the roof the details of the tiles are not so fully shown, as, owing to a foreshortening, they are not so clearly seen, and the forms in this distant roof are inferred from the nearer one. As the left side of the roof approaches the hip at the corner, the rendering of detail is gradually omitted, leaving the value white. This accidental light emphasizes the effect in the drawing in the same manner that the omission of the lines of the weather boards emphasized the drawing of Fig. **1**. There is no marking on the side of the house to indicate it as stone, brick, or tile, and it is safe to assume that it is of plaster or other

plain material. Were it built of large blocks of stone, they would be indicated by suggestions of the joints.

71. These few examples of roof rendering are sufficient to suggest modes of treatment for these and other textures whenever they appear. In the rendering of an old tile roof the treatment would not be greatly different from that of Fig. **1**; if the house were a new one, the lines would be more regular. A slate roof would require a still closer treatment in parallel lines, value being there the main consideration. Occasionally, all thought of texture may be laid aside in rendering a roof, especially in the case of the more distant parts. Such roofs may be rendered by a flat tone, the lines of which are generally in an oblique direction. In rendering a building of any kind, about the first consideration is to determine where to place large masses of light and shade. It usually happens that the roofs present the best opportunity for this, coming as they do against the sky, which is generally left white. If the roof is of such a material or character that it is desired to leave it very light, it will sometimes be necessary to give the sky a cloudy effect, or better still to introduce behind the roof line a mass of foliage. A cloudy sky should generally be avoided in the rendering of an architectural subject.

72. A Study in Windows.—In the rendering of all windows, small dark spots should be introduced to avoid the appearance of desolation likely to arise from drawing them as black holes. Windows appear as black masses only when all the glass is destroyed. When this is not the case the sunlight will play on the glass and sash bars and give a varied effect. The texture of the glass can be suggested by introducing spots of light or shade, or, when the drawing is large, by showing dimly through the glass the curtains or other details inside. The mechanical elaboration of the window frame or sash bars must be avoided if a total effect of sketchiness is desired. The true relations of light and shade are missed if too much attention is given to the accurate rendering of details.

73. In Figs. **5** and **6** are shown two windows with outside shutters. Their rendering is of a character consistent with the

usual architectural drawing and expresses all the details necessary for such work. Compare the different methods of rendering the shutters in Figs. **5** and **6**; in the first the stiles or frames are left white and profiled against the house by the shadow for an outline, and in the second the stiles are left black and the slats are indicated by short, black lines. In Fig. **5** the left-hand and lower boundary line of the shutter *a* is not shown, but is indicated by the shadow cast against the house. A similar treatment is given to the sill, but the shutter *b* is outlined, except at the bottom where the shadow is shown. This difference of treatment of shutters on the same window would at first appear unreasonable, but it should be borne in mind that the endeavour is not to represent everything seen, but to think of the window as a whole. If the left-hand shadow of the shutter *b* were drawn in, it would be found to interfere with the representation of the window sash, and the result would be lacking in clearness. Therefore, this shadow is omitted and merely the lower shadow that the shutter makes against the house is introduced. These details must constantly be considered in choosing methods of expression.

74. It is generally advisable to define the outer sash of a window somewhat sharply. This is best done by indicating the shadows rather than the objects that cast them; Figs. **5** and **6** are good examples of this. The left and lower portions are defined by narrow dark lines of shadow. In the lower half of these windows the glass is shown dark, while in Fig. **5** the sash bars remain light. In Fig. **6** there is no sash in the lower half of the window, so, in order to prevent a square black hole, a curtain is introduced hanging below the upper sash. The shadows that would have been cast by the shutters have been entirely omitted, because the shutters themselves are so dark that the shadow would be confused with them. The three windows shown in Fig. **7** are such as are usually seen in brick buildings. The treatment of each is slightly varied from that of its neighbour, but as a whole they present a uniform appearance and are plainly of the same type. In the rendering of a modern business building a large number of windows must be

represented, and this presents a difficult problem. In form, each window is a repetition of the others, but the light and shade should vary. In Fig. **7** the direction of the light is assumed to be the same as in Figs. **5** and **6.**

75. A difference often occurs in the shadow cast by the lintel and reveals of a window on account of the thickness of the walls in which the window is inserted and the distance from the face of the wall to the face of the sash, so that the treatment of the soffit, or under side of the lintel above, and the reveal at the side of each window should be carefully studied. It is a good rule never to introduce more than one large dark spot in a window ; therefore, in Fig. **7**, where the three windows are treated together, only one large spot has been used in the entire group ; this occurs in the lower part of *a*. A smaller spot is introduced in *b*, while to vary the effect the medium-sized dark spot used in *c* occurs in the upper part. The half tones are introduced into each of the windows to soften the effect of the spot and add to the glassy appearance. Fig. **8** shows a more ornamental type of window. There is nothing here essentially different from the previous examples, except the careful suggestion of ornamental detail by the drawing of the shadows. Outline in the details has been avoided as much as possible, except in the window frame, where some of the horizontal elements are shown in the upper part. The lower panes are shown dark, but they come so close together that they appear in composition as one spot. The triple window in Fig. **9** is from a country house. The diamond-shaped panes set in lead are characteristic of this architecture, and are rendered as explained in connection with Fig. **3.** Here, however, the treatment is more complicated. The effect of the window is sometimes introduced by making the panes black, while in other parts the pane is left white and the lead work drawn in. This gives variety, and expresses both the transparency of the glass and the reflection of the sunlight from it. Under the foliage, in places, the deep shadow obscures all the details. The mullions between the windows must be suggested very slightly, but not carelessly. Sketchy as this detail appears, it requires more careful pencil drawing than any of the previous examples.

76. Doorways.—Figs. **10** and **11** are typical entrances to houses. The suggestive treatment of panels in Fig. **10** should be noted, and also the free lines used in outlining the creeper. Little of the creeper is expressed, except on its shadow side, where an even tone indicates its under surface. In this sketch the light falls from a different direction than in the previous ones. In Fig. **11** the shadow is shown by cross-hatched lines immediately under the roof. This is the only case in this plate where cross-hatching has been used for a shadow, but here the depth of the shadow and the projection of the roof are best rendered in this manner. The shadows on the columns and other architectural details are rendered as simply as possible.

77. Foliage.—In architectural rendering it is necessary to introduce various accessories in order to break the monotony of line that is apt to occur, and to add life and interest to the subject. The principal ones are masses of foliage, such as trees, shrubs, and vines; horses and carriages; and figures, according to the position and surroundings of the object represented. Figs. **12** to **15** are illustrations of typical foliage. In the introduction of tree forms there are two important considerations: first, the determination of sizes, what general shapes, and what values should be used in the composition in order to establish a balance and maintain a rhythm, and at the same time preserve harmony between the appearance of the building and the forms of the masses with which it is surrounded; second, it is important to introduce only such types of growth as would naturally be found in the locality of the building.

78. If the drawing is to be made from a photograph of a building that already exists, some minor objects may be changed in form. It is quite proper to enlarge or curtail or vary the outline of a tree or vine; such changes will not falsify the general appearance. Neither need one feel bound by the actual values indicated in a photograph, for a photograph seldom renders values with any degree of accuracy. The high lights are usually brighter and the shadows deeper and more opaque than they appear in nature. They need to be adjusted when reproduced in pen-and-ink rendering. If the building is not yet erected, much

more freedom may be used, and the choice of such accessories as shrubbery, trees, etc., may be governed entirely by good taste.

79. In Fig. **12** is a very light treatment suggestive of the upper part of a group of poplar trees, the lower part being hidden by low masses of foliage. The character of the poplar is so marked that it cannot be mistaken if only the outline is well indicated. This is characteristic of a number of trees, as is shown in Figs. 26 to 29

FIG. 26

FIG. 27

of the text. However, where trees grow near together, or are seen at a distance in masses, it is not easy to distinguish the different kinds. In Fig. 26 of the text is shown the general character of the outline of the poplar as it should be drawn in pencil before the rendering shown on Fig. **12** of the drawing plate is attempted, while in Fig. 27 of the text is the characteristic outline of the apple tree. The oak

FIG. 28

shown in Fig. 28 and the American elm shown in Fig. 29 of the text are further examples, and their characteristics should be

studied by the pen draughtsman if he would properly indicate them. In rendering these trees the outline should be drawn in pencil and not inked. The mass of foliage, if the trees are distant and unimportant, should be laid in in an even tone, the lines of the pen running as nearly as possible in the direction of the lines of the foliage. But where the trees are nearer and a more careful rendering is desirable, the tones can be varied, as in Fig. **12** of the drawing plate, and strong, high lights introduced to give life to the composition.

Fig. 29

80. In Fig. **13** is shown a mass of foliage that might be used as a background at the side of a house, or in some place where a dark spot is required in the composition. In Fig. **12**, the colour values of the trees are not given and no outlines are used; only the shadows are touched in by the use of short lines that help to give the effect of leaves. The absence of outlines gives the effect of air and sunlight, for the constant moving in nature prevents our seeing any distinct outline. In Fig. **13** an outline is shown, but note how the effect of the dark mass is softened by the addition of the finer and very irregular lines. In this case the atmospheric effect is helped by the outer lines, for if the broad dark strokes that make up the strong value of the trees were left at the edges, the result would be hard and crude. Where a dark tree appears against the sky the edges appear lighter than the mass of the tree. Touching the edges of the dark masses with lighter tones or outlines is an attempt to suggest what is true in nature.

81. In Fig. **14** is shown a loose and free treatment often needed in the suggestions of foreground study. There are infrequent occasions when the immediate foreground may require

a detailed representation of trees, at which time a few should be carefully drawn. One or two well-defined and shaded leaves backed by several small masses of shadow will express much more than a number of poorly rendered details. Fig. **15** is a young maple tree represented entirely in shadow. The trunk should be drawn with great care, giving a proper sense of strength and vigour. Note the gradual diminution of its size as it leaves the ground, so that it is smallest immediately under the burst of the foliage. All saplings are of this general type, elms as well as maples. These are appropriate trees to introduce into the foreground of a building in a new district. The young tree is in harmony with the development of a new or young district, and the small mass of foliage at the top of the tree does not interfere materially with the view of the structure.

82. It is necessary to study nature constantly. Make sketches from photographs, or from actual trees, and practise in the rendering of these accessories. A collection of these sketches is part of the stock-in-trade of every draughtsman and every illustrator. In sketching from nature, always look for large masses and characteristic lines, as these will give a freedom of rendering and touch. Sketch any object that interests you ; do not imagine that you can draw it from memory when wanted. A visit to any artist's studio will convince you that none of his illustrations or pictures are made from memory. Thousands of sketches and bits of detail are recorded by him from time to time to be laid out as notes from which to build up his finished study.

83. Figure Rendering.—There should always be more freedom and lightness of touch in handling natural forms than in handling architectural forms. The contrast gives interest to the picture. The addition of figures adds interest and serves also to give scale to the other objects, because one compares heights to the size of persons ; but a good picture may easily be spoilt by the introduction of badly drawn or badly placed figures. In other words, a good composition can be spoilt by introducing figures that destroy its effects. In the case of trees and foliage, or of people, they should be such as would be found

in the neighbourhood of the buildings shown. Of course, almost any kind of person might happen to be in front of any building, but that is not considering harmonious composition. Introduce only such individuals as would be likely to be seen there. A procession of soldiers would not be a proper element to introduce into the foreground of the drawing of an old monastery, any more than a procession of monks in the drawing of an armoury. In the same manner, Fig. **17** would not be proper in connection with the old English cottage. In the composition called A Country House it would not do to introduce a street sweeper, such as is shown in Fig. **21**, and which would take its place quite appropriately in connection with a city building. In introducing figures in a picture, composition should always be the first consideration. Figures must always be considered as spots of value, and must be so placed that the balance of the picture will not be destroyed.

84. The laws of perspective must be kept constantly in mind, as a figure out of scale will destroy the effect of the entire

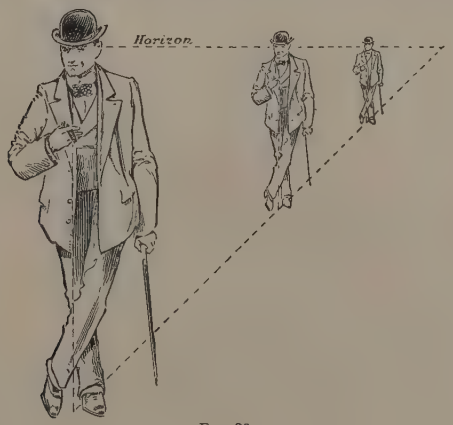


FIG. 30

composition. A person of average height standing on a street level will find that the heads of the people about him, whether near by or far away, will appear at about the same level as his own.

The more distant figures appear smaller than those near by, but the diminution in height is entirely at the foot end. Their heads are always on a level with one another, as shown in Fig. 30 of the text. Figures should appear in natural attitudes when grouped about a building, and when standing still should be engaged in conversation; at least, some excuse for their standing still should be obvious, otherwise they will appear like dolls. The majority of figures seen out-of-doors are moving, and snap-shot photographs will give a series of them.

85. Figs. **16** to **24** suggest the kinds of figures that will appear most useful; they also show the methods of rendering such figures. No small details are shown. Features are simply suggested or indicated, and in one or two cases not indicated at all. Only in Fig. **16** are such details as buttons indicated, and in this case they are necessary, as the large brass buttons on the coachman's coat are suggestive of his position. In sketching figures, either from nature or from photographs, work only for the long lines and the larger forms.

86. The key to the proportioning of the figure is the head. The size of the human head varies but slightly in different individuals, and there is less growth of the head from infancy to adulthood than in any other part of the body. In adults, the length of the head constitutes from one-sixth to one-eighth of the whole height of the person; therefore, the first question to be settled is the number of heads in height to be given a subject. A figure only six heads high looks short, as shown, for example, by the woman in Fig. **16** of the plate, where the head is about one-sixth of the whole height. The actual height of the coachman, exclusive of his silk hat, is about that of the woman, but he gives the impression of being much taller. His head, allowing for the part covered by the hat, is about one-seventh of the total height. Fig. **17** gives the impression of being a tall woman; she is about seven heads in height. Compare the sizes of the heads in Fig. **22**. While they are not very different in size, the little girl is about five and one-half heads in height, and the woman is nearer eight heads, which is very tall. A figure should never be made over eight heads in height,

unless it is desired to give the appearance of unusual height to the person so represented.

87. Care should be exercised in sketching figures to avoid the appearance of their toppling over. If a figure is standing, a line should be drawn from head to foot to show that the centre of gravity is over the centre of support. In drawing consider the head as an oval. Carefully mark the position of such parts as shoulders, elbows, waist, and hips. Refer the length of the arms to a point half-way between the top of the head and the base of the feet. It will be found that the arm hanging by the side will fall below this centre point.

88. The study of Fig. 31 of the text will help in the sketching of figures, where the heights in each case are divided into eight heads by the vertical line marked as shown. As figures recede into the distance, less and less of the detail appears, as will be observed in Fig. **19** of the drawing plate, where scarcely more

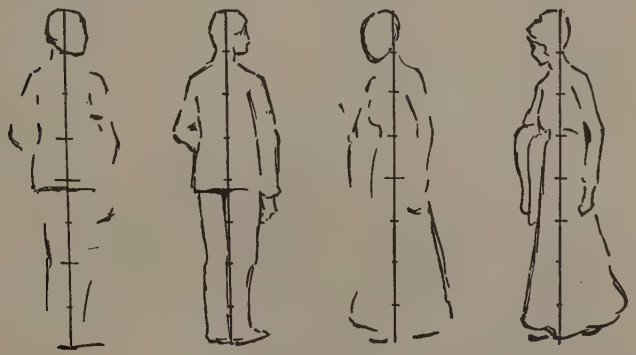


FIG. 31

than a few spots of light and shadow are indicated. While Figs. **16** to **21**, and **23** give some indications of colour as well as texture, the other figures show hardly anything more than shadows, although in Fig. **22** the hair and stockings of the little girl and the hair of the woman are given a slight colour value. In Figs. **18, 20, 22,** and **24** the cast shadows are shown on the ground. In the others, little of the light and shade is

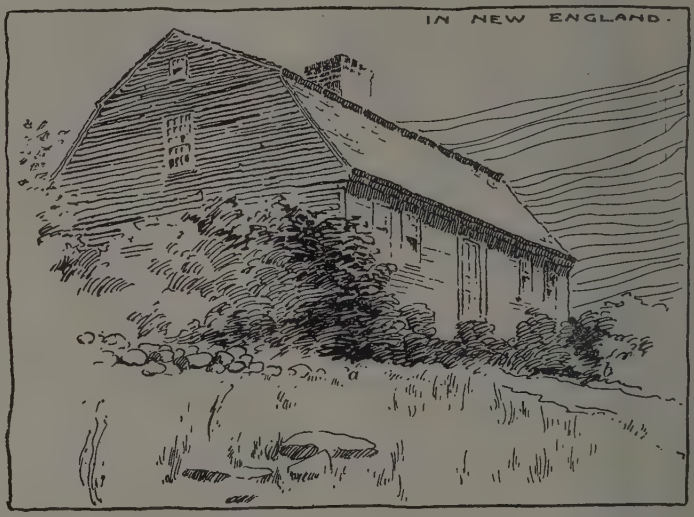
indicated, the colour values giving the principal effect, as was observed in the shading of the girl in Figs. 1 and 2 of the text.

89. While figures require as accurate drawing as any part of the picture, they must be rendered with a free, elastic touch; the T square and set-square are of no use here. The aim of the artist is to express life, the power to move, a contrast to the immobility of the architecture with which they are often used as accessories. In drawing figures, one may vary them to suit the fancy, taking the subjects from photographs or from nature; but care should be exercised to follow the principles herein set down and to work as closely as possible in accordance with the foregoing instructions. The title may then be drawn at the top of the plate as before, and the name, date, class letters, and number inserted in their usual places.

DRAWING PLATE, TITLE: TYPICAL SUBJECTS

90. The work on this plate is devoted to four subjects, varying in character and illustrating the principles of composition and technique that have been set forth previously. An outline drawing of the figures on this plate is shown on a separate sheet, but before commencing the rendering of this, each figure should be drawn in pencil on a separate sheet, and carefully rendered, so that no mistake may be made on the finished sheet. In rendering Fig. **1**, note that the principal dark mass of the foliage is at *a*, and is a little below the centre of the picture. This is reinforced or strengthened by a larger mass of half tone that forms the end of the house. In rendering this half tone, attention should be given to the texture of the house; that is, the lines forming the half tone should be used to suggest the weather boards. This large half-tone surface attracts the eye first after the mass of dark at *a*, and the balance of the composition is maintained by the introduction of another small dark spot at *b* and by the half tone connecting the two spots. The spot at *b* is reinforced by the light grey of the sky. The result of all this is that the centre of balance of all these spots of value falls about the centre of the picture.

TYPICAL



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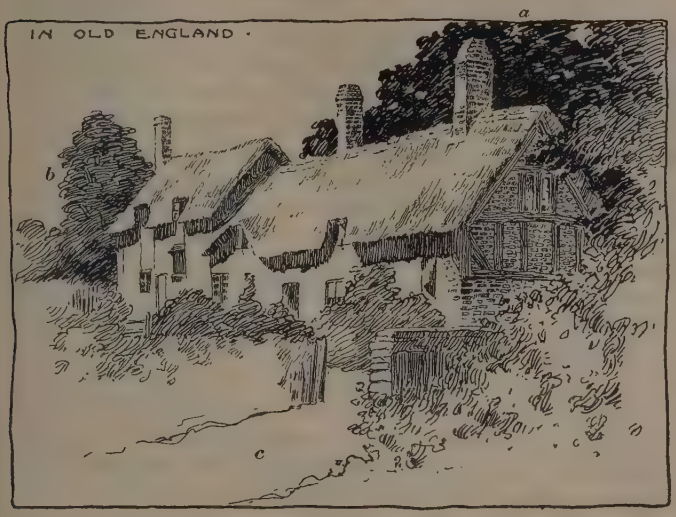
SUBJECTS



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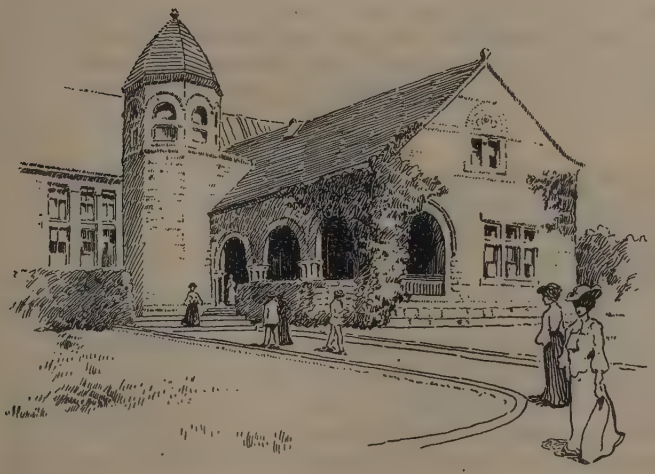

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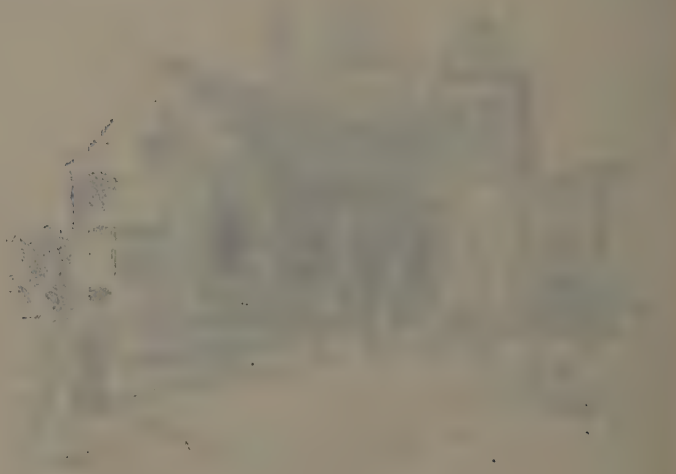


91. In Fig. **1**, five values are used, including white and black. These give a brilliancy of effect that is entirely free from harshness of contrast. The textures are in no way different from those practised on previous plates. The sky as rendered here is an exception to what is generally considered good practice, for a tone is not advisable on what should appear to be the lightest part of the composition. In this case, however, the darkening of the sky is permissible in order to set off the roof and to form a background for that part of the composition, and to assist the perspective. The weather boards on the front of the house are only very faintly suggested, so as to give the idea of full sunlight on this side. The same treatment is given to the tiles on the roof, although no doubt is left as to the fact that the roof is tiled. A few touches are employed in the foreground to indicate long grass growing among the rocks, but no attempt has been made to render this in any detail. Much can be learnt by studying the manner in which the darker parts of the picture have been connected with one another. The front of the house, being light, attracts the eye to the centre of the picture, and this whiteness is further emphasized by contrast with the dark masses of foliage. The windows are merely indicated so as to prevent their cutting up the side of the house. The brick chimney is treated with only sufficient detail to show that it is brick. This method helps to convey the impression of oldness, which is still further intensified by the heavy growth of foliage, grass, and weeds.

92. In Fig. **2** is an old farmhouse with thatched roof and timber construction, which shows through the brick filling on the end. The most difficult thing to render in this composition would be the foliage, but if the figure is first carefully drawn in pencil, in a similar manner to the model shown in the outline plate, the entire attention can be devoted to the rendering. The effect of the dark mass against the sky at *a* is not softened by finer lines, but at the edge a fine line is used to relieve the abruptness of the heavier strokes. In sketching foliage in this manner, the roundness of the masses and the appearance of thickness must be suggested without any attempt to indicate the individual

leaves. In the mass of foliage shown at *b*, the lines are much finer and more open than those used to indicate the nearer masses. This handling softens the effect and gives distance, or perspective, to the picture. The mass of foliage at *a* forms the principal dark spot of the composition, and is contrasted against the light roof of the cottage so as to throw the latter into prominence. The harshness of this dark spot is relieved by blending it into the half tone of the nearer foliage, as well as by the middle tone indicated on the end of the cottage.

93. The values at the right of Fig. **2** are connected to those at the left by the small mass or line of shrubbery running along the fence and wall. The path *c* leads the eye from the lower left-hand corner of the picture through the gateway to the house. If this path or the foreground about it were carefully and elaborately detailed it would divert attention from the building, which in reality forms the centre of attraction. The bulk of the cottage surface being white, this path also serves to connect the high lights ; it should always be remembered that the various dark masses or the light masses should be connected together in order to give unity to the composition. The treatment of the chimneys is here even less suggestive of brickwork than in Fig. **1**, and in the end of the cottage between the timber beams the brickwork has been indicated in a broad and suggestive manner without expressing too much detail. The lines of the shadows under the eaves should be slowly and carefully drawn and accented at their lower ends so that they run together. These shadows do not end in an even line, but express by their uneven terminations the character of the thatch that casts them. The thatch on the roof is indicated by the fewest possible lines, but along the eaves and the gable it is so rendered as to convey the impression of great thickness. It will be observed that the extreme outside and corners of this picture have not been filled with any details. This method of treatment is called *vignetting ;* it is used to keep the eye at the centre of attraction.

94. One of the greatest difficulties in rendering a drawing is to tell when to stop ; experience alone seems to advise the artist when he has worked enough. It should be remembered

that as soon as the desired effect has been obtained, the picture is finished and every other line is unnecessary. It should also be borne in mind that the rendering of detail should be as sparingly used as possible. A well-rendered drawing, from a technical standpoint, is one in which the effect has been obtained with the fewest lines, and it has been well said that the art of pen-and-ink work consists in knowing what to leave out, rather than what to put in.

95. Fig. **3** is a view in the streets of a mediæval town in Germany. This requires very careful pencil drawing, in accordance with the details given in the outline plate, preparatory to rendering. It is quite simple to render in pen and ink, as the tones are not complicated or greatly varied. Here the darkest spot in the picture is near the centre, a point to which the lines of the street naturally lead the eye. It is the shadow between the arch, and is much smaller than the leading dark spots on Figs. **1** and **2**. The comparatively large areas of half tones are so disposed that they practically surround the central part of the picture. This disposition tends to direct the eye to the centre of the picture quite as much as does the dark shadow surrounded by an area of light. The half tones on the left of the picture are formed by the shade side of the buildings, those on the right by the roofs. These roofs are rendered in simple half tones without any attempt to indicate their materials. They are probably tile, but the quaintness of the village street is so interesting in itself that one is satisfied without indications of the detail of either the roofs or side walls, except where it is necessary to give variety or to indicate structure, such as the arch stones suggest.

96. On the right of Fig. **3,** the combination of the figures in the foreground, the slight suggestion of a vine over the doorway, and the shadow of the eaves serve to break up the wide area of light and balance the composition nicely about the centre. The introduction of these figures at this particular spot in the picture is of interest from the point of view of composition, and the small dark spot in one of the figures is interesting as showing how variety can be obtained by very simple methods. The

large area of light on the right-hand building needs a dark spot in the lower right-hand corner in order to maintain the balance; and the introduction of this group of figures with the particular values that they possess is an excellent illustration of the right and proper use of figures as accessories. Simple and suggestive as the outlines of these figures are, their costumes are in perfect harmony with the quaint character of the place.

97. Fig. **3** is so small that the treatment of the windows is of the crudest and most suggestive character, but the study of windows on the previous plate will show how to render them and to indicate the shutters, etc., that form prominent dark spots on the face of the building. Observe how slightly the buildings beyond the archway are indicated, and be careful not to give them too much prominence. The face of the clock in the picture is carefully represented; not carefully detailed, but carefully suggested. No particular numerals are indicated and the hands are scarcely more than hinted at, but one can easily see that it is twenty minutes past ten. This is of no importance whatever to the drawing, but it shows how much can be conveyed with a very few strokes. In rendering this drawing, care should be taken to keep the lines light and steady, and not to overdo the rendering.

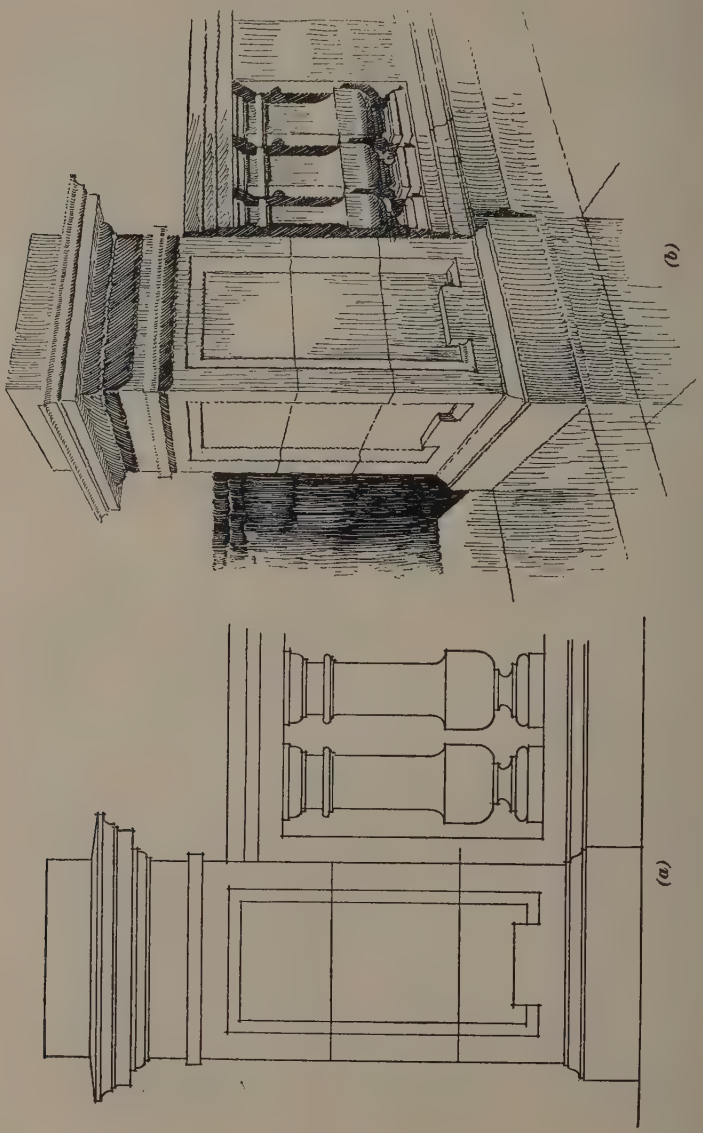
98. Fig. **4** is a perspective rendering of a building which presents the character of the average architectural problem in pen-and-ink drawing. Here a stone building with a slate roof and accessory foliage is to be rendered, so that the material will be indicated without being shown in detail. The use of lines suggestive of stonework or brickwork, as in Figs. **1** and **2**, will give the appearance of age or antiquity, which is to be avoided. Neat, crisp strokes must be used, and the figures introduced must have an up-to-date appearance; those used in the last example would be greatly out of place. Figures must not interfere with the lines of the building itself, but at the same time they must balance the composition. The rendering of the roof has been confined to the simple representation of a value by means of sharp, crisp lines corresponding in direction to the courses of slate with which it is covered. The windows and the arches of the porch require the greatest care;

the former, so as to suggest the reveals, or thickness of the walls, and the latter to show the soffits of the arches and the deep shadow cast by them on the porch. Observe, in comparison with Fig. **1,** the treatment of the grass. Few lines are used, but by their short, straight, and generally perpendicular position they suggest a mowed lawn. The stonework of the building is indicated by few touches at the angles and about the windows, without any attempt to outline individual stones. The darkest mass of the picture, the shadow of the arches over the porch, is near the centre. The end of the building, in full sunlight, is relieved somewhat by the suggestion of foliage just behind it and the two figures in the foreground. Observe how the figures diminish in size as they recede from the eye, and that their heads are all at the same level, and that the spaces between them are unequal. All these details are of importance. After rendering this plate, place the title in its proper position, and the name, date, class letters, and number below the border line, as usual.

RENDERING ARCHITECTURAL PERSPECTIVES

99. Perhaps one of the most usual problems that confronts an architectural draughtsman is the rendering of a perspective drawing set up from geometrical drawings. But the pencil outline should be readily made if *Perspective Drawing* has been carefully studied, and the shadows should be put in by the methods described in *Shades and Shadows;* the perspective should then be easily rendered if the preceding pages and drawing plates of this Section have been mastered. But this branch of the subject should be thoroughly understood, for it is advantageous to an architect to show a client a perspective view of the building for which he has prepared the plans. Figs. 32 to 35 are given as an aid in rendering perspective drawings, but they must be considered only as examples, for the same subject may be rendered in many ways.

100. In Fig. 32 (*a*) is shown the geometrical elevation of a pier and balustrade that might be used as a boundary to a terraced garden or as an enclosure to an entrance way. From



(b)

(a)

FIG. 32

this drawing it would be difficult for a client unable to read an architect's drawings to grasp what the finished work would look like ; but should the architect submit to him a perspective sketch rendered as shown in (*b*), he would at once be able to say whether or not he was pleased with the design. The work shown in (*b*) is rendered in a free manner and bears no indication of laboured effect. It will be noticed that the balusters are not outlined, their shape being formed by the shadows they cast. In the same way the mouldings to the cap of the pier are shown more by suggestion than by the use of hard straight lines bounding their profiles.

101. In Fig. 33 is shown the corner of a building in geometrical elevation as prepared in a set of architect's working

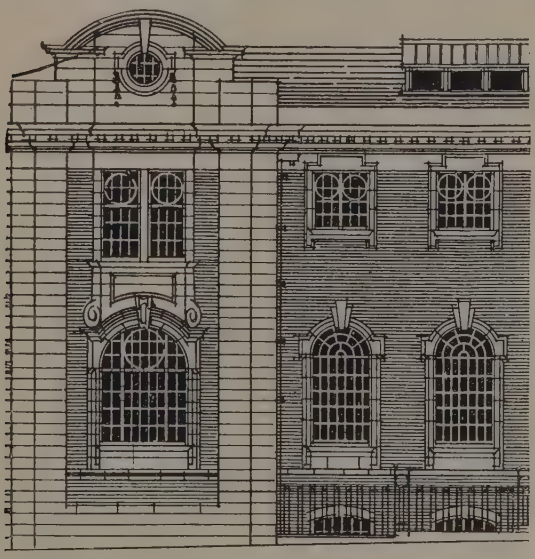
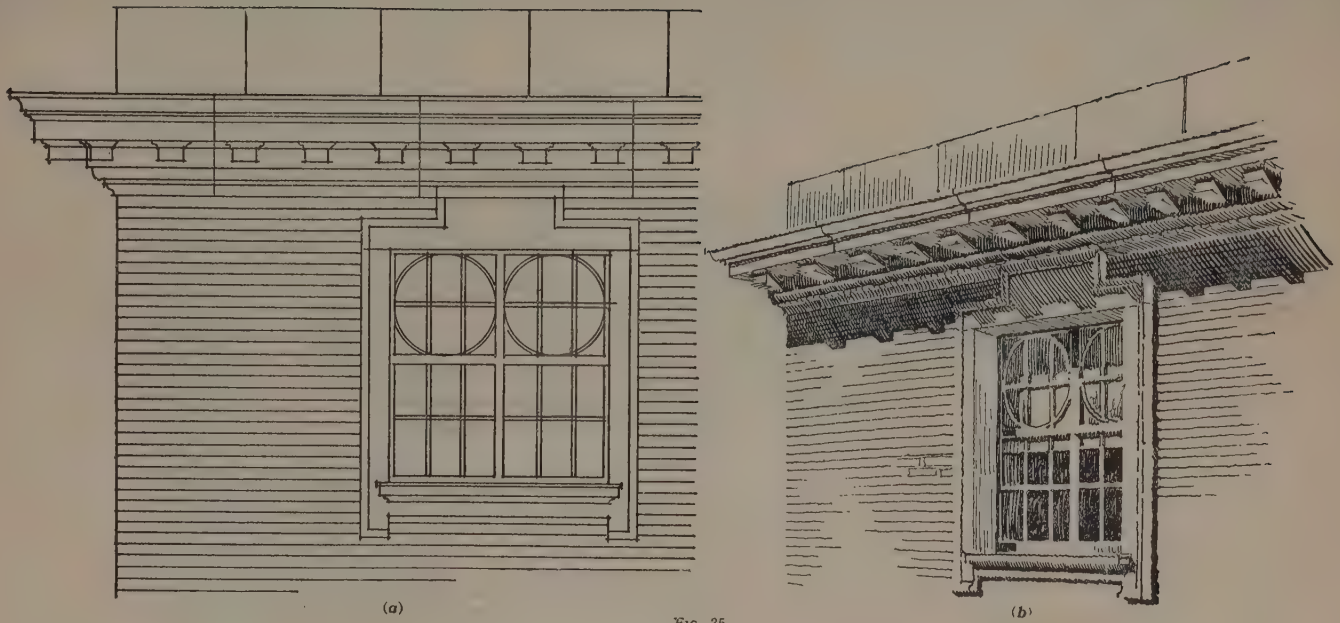


Fig. 33

drawings. The building is chiefly of brick facings, with stone dressings to the pavilion and to the windows and main cornice. An architect, or one trained in the reading of drawings, would

be able to form a very good idea of what the finished building would look like from this elevation, but to the uninitiated the perspective sketch of the same building shown in Fig. 34 is very much more clear. This sketch would be set up in perspective and rendered in any manner desired, the method shown in Fig. 34 being only one style. It will be noticed that in some small particulars the perspective varies from the geometrical elevation. For instance, in Fig. 33, under the lower window of the pavilion, is shown brick filling to the wall, but in Fig. 34 this is shown to be in stone. This alteration may have been made by the artist, who was desirous of making a pleasing picture and thought that the stone filling would tend to that end; or it may have been made by the architect, who, when he saw the building set up in perspective, decided to alter his design to give what is undoubtedly a more pleasing effect. It will be noticed in Fig. 34 that the idea of brickwork is obtained by means of the broken wavy lines, while the stonework is left almost white, only a slight amount of work being put upon it in places to give a feeling of relief.

Fig. 34



(a) (b)

FIG. 35

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FIG. 36

The figures introduced in the foreground give a sense of scale and proportion to the building and help to break the otherwise uninteresting line at the bottom of the picture. The cornice with the deep shadow under it has been rendered in a free manner, yet the idea of its design is clearly shown.

102. In Fig. 35 (*a*) is shown a detail of the main stone cornice and window under same designed for the building shown in Figs. 33 and 34. This is purely a geometrical elevation, showing the joints of the brickwork, the profile and jointing of the cornice and blocking course, and the size and design of the window. A perspective rendering of this subject is shown in (*b*). The brickwork is indicated by slightly wavy lines suggesting the unevenness of the material ; the angle or corner of the building is not drawn in with a hard line, but is indicated by the stopping of the brick joints. The cornice is well suggested, and it will be noticed that the shadow under it is much darker on the brickwork than on the stone, which would be the case in reality. Each line in the drawing has a certain feeling about it, and much of the effect is obtained by the constant breaking of many of the lines, though care must be taken not to overdo this. The treatment of the window shows how monotony can be avoided by a little thought and study ; the blind inside is half drawn, which gives a good opportunity for contrast in tones, while the white specks which have been intentionally left in the eight lower panes shown give a much better effect than if they had been filled in quite black.

EXAMPLES OF WORK

103. D. A. Gregg.—Among black-and-white artists D. A. Gregg takes a very high place for his straightforward and thoroughly understood architectural rendering. Observe in his view at Vire, Fig. 36, how the texture of each surface is clearly indicated by a series of well-placed lines, and yet the entire rendering possesses even tones free from obtrusive spots or contrasts. Notice, also, how the shades are connected so as to lead easily from one to another ; the methods of producing these effects are worthy of study. Most of the shadows are rendered by vertical lines, but

in the shadows of the projections of the tower, the lines of the stonework are simply emphasized to give the effect. It is interesting to see how the tower is emphasized by making it the largest dark mass of the picture, and also by giving explicit attention to its details. The drawing is open to criticism,

Fig. 37

however, as being a trifle too laboured, and in that respect is suggestive of a photograph.

104. Quite a different method of rendering is shown in Fig. 37, where a portion of one of D. A. Gregg's drawings, to an enlarged scale, is shown. The enlargement shows the kind of line used.

It should be noticed how sparingly outlines are employed, which is a characteristic of this artist's work ; yet, even if the suggestions of detail are often very slight, they are always precise. The effect of a flood of sunlight is well obtained by means of the great contrast between the foliage and railings with the deep shadow they cast on the left-hand side of the picture, and the plain paper and slight rendering on the other side. Particular note should be made of the boldness of line used throughout this rendering.

105. Another example of rendering by D. A. Gregg is shown in Fig. 38, where a portion of one of his compositions has been

Fig. 38

taken and enlarged to show the quality of line and method of rendering. It will be noticed that here, again, no portion of the subject is outlined in any way. The path is formed simply

by stopping the rendering on the grass, while the trunks of the trees and the trees themselves are formed by suggestion; yet there is no mistaking the individual parts composing the subject. By copying some of the enlarged portions of sketches here shown an idea will be gained of the methods used by men thoroughly conversant with their art in obtaining different effects. They should be copied only to gain this end, as every man must work out a style for himself.

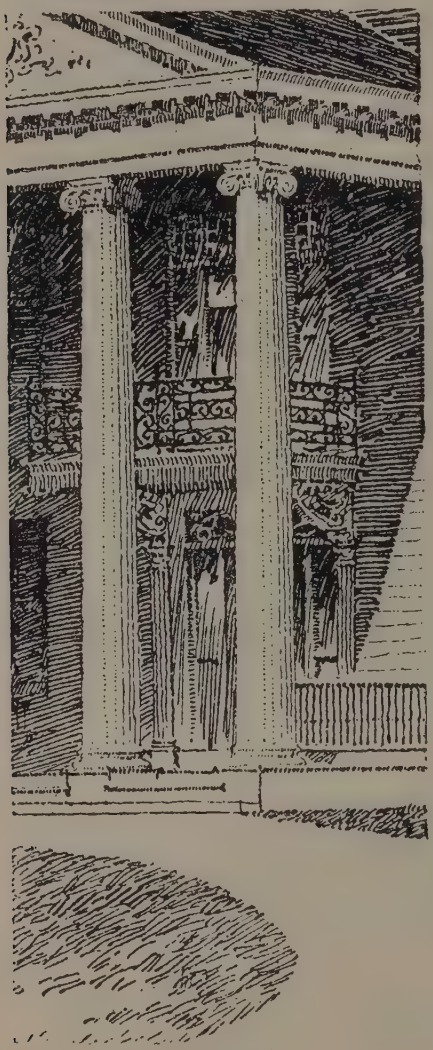

FIG. 39

106. One more example of the work executed by D. A. Gregg is shown in Fig. 39. This also has been considerably enlarged to give an idea of the artist's methods. A classic porch is not the easiest subject to render, with its circular columns and deep recess in shadow, yet it has been most successfully treated in this instance. The columns

with their bases and caps have merely been suggested, the chief

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FIG. 40

effect being obtained by what appears to be a series of dots.

This is a most difficult method of rendering, for one or two dots put in the wrong place will spoil the whole effect. Again, the cornice and entablature over the columns have been shown merely by suggestion, there being hardly any outlining of individual members in the rendering. The deep shadow under the recess of the porch has been most successfully treated in a bold and dashing style, yet it has a feeling of transparency and an atmospheric effect, so difficult to obtain, yet so strongly characteristic of all this artist's work.

107. Bertram G. Goodhue.—Another architectural draughtsman whose work should be carefully studied is Bertram G. Goodhue, for he characterizes his renderings by a careful drawing of details and due consideration of broad effects of light and shade. The church in Fig. 40 shows freedom and refinement of handling and a bright sunny effect that is delightful to the eye and serves to present the architectural design to advantage. The textures illustrated here are worthy of study, as is also the sparing use of cross-hatching. There are places where Goodhue has found cross-hatching a convenient and direct method of accomplishing certain purposes, but it is never introduced except where required. It must be remembered that this drawing, like all of these illustrations, is much reduced from the original size, and that the pen lines appear very much finer and closer together than they were drawn, although, of course, they remain in the proper proportion to the size of the drawing. Goodhue, however, uses his lines in a somewhat closer manner than Gregg. A comparison of the styles of these two men is interesting, especially their methods of handling foliage.

108. A portion of a drawing by Goodhue, to an enlarged scale, is shown in Fig. 41 to give an idea of the method used by him to gain his effects. This drawing particularly well represents texture and lighting. A glance shows that the sun is shining with great brilliance. The very clever representation of materials is perhaps the most striking characteristic of the sketch shown in Fig. 41, yet the drawing is perfectly free and not in any sense laboured. The brickwork over the doorway, with the carved stone head, giving a clear impression that the

stonework is somewhat decayed, and the rendering of the stonework to the general wall face on each side of the doorway are

FIG. 41

exceedingly well rendered. But perhaps the most striking feature of the composition is the rendering of the iron railings on each side of the steps; here the rendering of material and

light and shade, together with the cast shadow on the steps, is well worth study. Quite a different feeling is obtained when

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FIG. 42

a different material is depicted, as, for instance, the wood of the entrance doors or the glass in the windows.

109. Frank A. Hays.—Fig. 42 is a rendering of an old mansion, by Frank A. Hays, which is well worthy of study on account of

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FIG. 43

the delicate and sketchy handling. Yet it should be remembered that the drawing must originally have been made very carefully, in order that the few lines with which it is rendered could be

properly placed. The introduction of the creeper climbing up the corners of the house is very pleasing and is simply rendered. The study of foliage by different pen artists is interesting and instructive, as each finds a way for himself to convey the idea. The sketchy treatment here gives the impression of an old mansion. It would not be an appropriate thing to transfer this handling to the rendering of a new house, though that mistake is sometimes made by architectural draughtsmen in their anxiety to produce picturesqueness.

110. Ernst Peixotto. — The drawing of Lincoln Cathedral shown in Fig. 43, by Ernst Peixotto, is a good example of balance in a composition. Note how the artist has drawn the left-hand corner of the picture simply in outline, while he has massed his principal tones in the centre of the picture, emphasizing his middle distance, as it is termed. The relief given above the roofs of these houses by the indication of trees and other houses in the distance, the whole of which are merely suggested, should be particularly studied, as they bring out by contrast the greys of the Cathedral building beyond. The whole picture is indicative of a particularly sunny effect.

111. Martin Rico.—Martin Rico is a Spanish artist whose methods have taught a valuable lesson to scores of students. He is noted for his ability to indicate textures and preserve the transparency of his shadows so as to show the texture of objects, even in shadow. His renderings of Venetian subjects in full sunlight are brilliant in the extreme. His use of line is sketchy, but is in its way most admirable. The pen drawings of Martin Rico have almost the qualities of paintings, so strongly do they suggest colour. His lines are so used that they are forgotten in the tones which they form ; yet they are used with economy and technical skill. Such freedom and adequacy of handling is the result only of full artistic knowledge. The figures are spotted in so as to give an excellent impression of movement. Their impressionistic treatment is hardly within the range of the beginner. Fig. 44 is characteristic of his work and shows a Venetian by-way, wherein the deep shadows are strongly suggestive of a full and brilliant play of sunshine that

makes one feel the climate and the atmosphere. It will be

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FIG. 44

noted, however, that the flowers in the pots on the balconies under the windows and the foliage extending above the wall in the

distance are indicated with the fewest possible number of lines,

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FIG. 45

and suggested in such a subtle manner that one feels their

presence without really looking for them or knowing that they are actually drawn there.

112. In Fig. 45 Rico shows only one side of the street, although the deep shadow indicates that buildings on the opposite side cut off the brilliant sunlight that floods the rest of the composition. Observe the texture of this shadow, and what a difference there is in the texture of a shadow where it falls in the street and where it falls on the walls of the buildings. There is no cross-hatching in it, and yet the roughness of the street is fully indicated and contrasted with the smoothness of the walls of the building. The introduction of the figures adds interest and gives life to the drawing without in any way detracting from the character of the surrounding work, while they contrast admirably with the texture of the walls and street.

113. Maxime Lalanne.— Quite a contrast with the preceding methods of working are the sketches by Maxime Lalanne, whose manner is delightful and unaffected. There can be

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FIG. 46

little doubt that Lalanne's method is simplicity itself, as shown in Figs. 46 and 47. Note, in Fig. 46, all the details of the château; the distant elm tree and the bank in the foreground are clearly expressed without an unnecessary line. The details of Fig. 47

are worked up somewhat more fully, but the full sketchy appearance is maintained admirably. Lalanne depends largely on outlines, and introduces his half tones merely as suggestions to dignify and solidify the structures. The architectural sense of the artist appears strongly in his slightest suggestions of a building. Compare the lines employed in the outlines of the trees with those of the buildings in Fig. 47. There are many draughtsmen whose methods are more captivating at first sight, but there are none whose drawings are better in style than

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FIG. 47

Lalanne's. His drawings show that he understands and sympathizes with the architecture he renders, as he indicates nothing in a hazy or uncertain way; each line is drawn to represent something.

114. Herbert Railton.—The work of Herbert Railton, shown in Fig. 48, is in strong contrast with that of Maxime Lalanne's. Herbert Railton's work is rich in colouring, brisk and clever in technique, and quite fascinating in style; it is full of variety, and very clever of touch. It possesses a dash that is certainly

absent from such drawings as Lalanne's, and Railton therefore has many would-be imitators. There is much to be learnt

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FIG. 48

from this work, but one must be careful not to be carried away by the clever treatment and elaboration of the details. The

particularly sunny effect obtained, together with the simplicity of technique, make this sketch one well worth study. Special note should be taken of the rendering of the brickwork at the

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FIG. 49

left-hand side of the picture, and the gable of timber and plaster filling in the full blaze of sunlight.

In Fig. 49 note how important a part the two figures play in the composition. This can be seen by covering them and noting

the change of effect. In Fig. 50 the treatment of old brickwork should be noted, remembering though that this is old

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FIG. 50

brickwork, partly covered with plaster, and that such treatment cannot be appropriately applied to new brickwork. Of the three sketches illustrating Herbert Railton's work that

shown in Fig. 48 is perhaps the simplest in technique, therefore offering the most help to the student.

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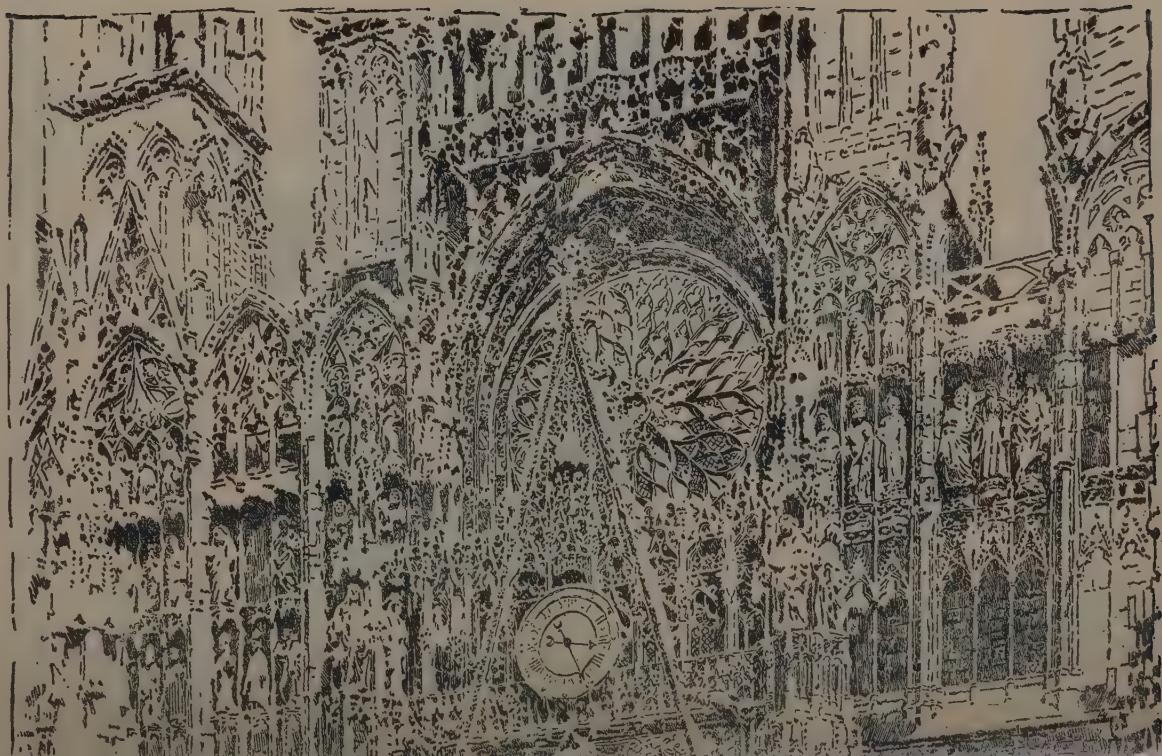
FIG. 51

115. Joseph Pennell.—Joseph Pennell is an American who has distinguished himself not only as a pen-and-ink artist, but



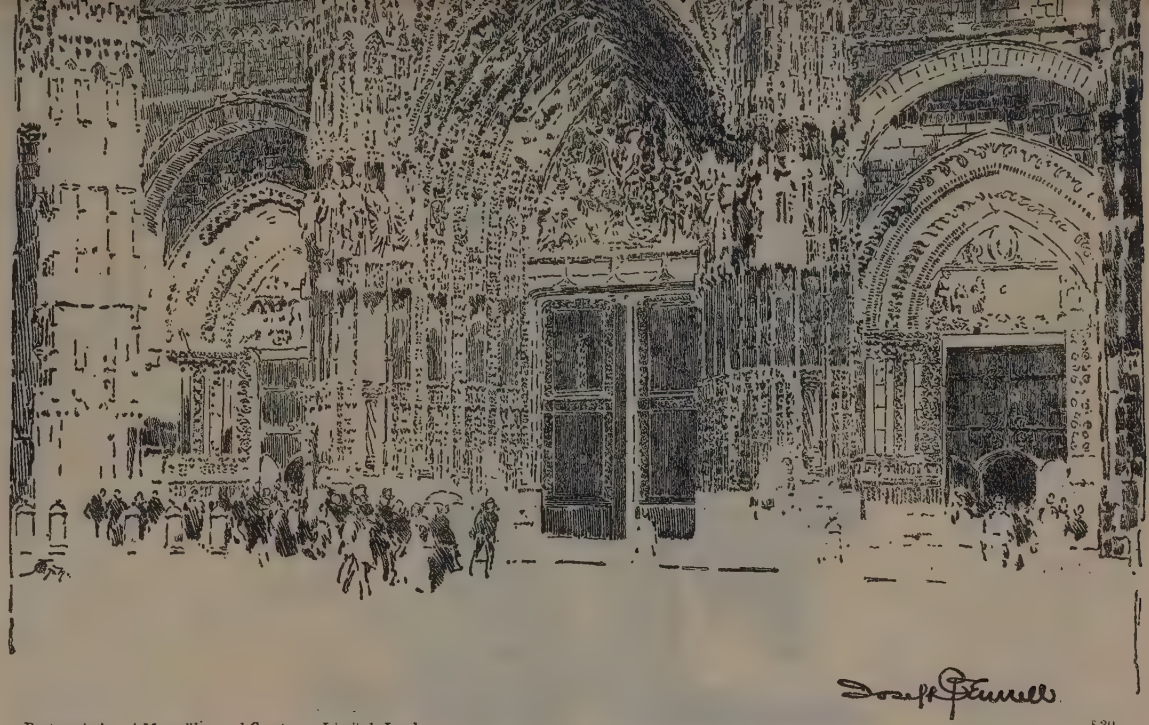


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FIG. 52

§ 30

as an etcher. His subjects have been largely architectural, and it is not difficult to detect in some of his work the influences of such artists as Vierge and Rico. Whatever artists he may have studied, there can be no doubt that Pennell's handling of the pen is original and quite his own. He suggests light and

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FIG. 53

air at the same time that he represents the charm of architectural groups of buildings or of picturesque nooks and corners. He uses the pen freely, but with full knowledge that every line acts in the effect, that an extra line is wasted, and that nothing must be omitted. Figs. 51 and 52 are excellent examples of his

rendering, and illustrate how carefully he has studied the architectural detail of his subjects as well as the atmosphere in which they exist. An artist must do more than draw a portrait of his subject; he must suggest its surroundings in such a manner that one feels the very atmosphere in which he draws. The sparing use of darks gives to Fig. 51 the light and outdoor feeling that is so noticeable.

116. Fig. 52 is a copy of one of the finest examples of Pennell's work, representing as it does a study of a portion of the west front

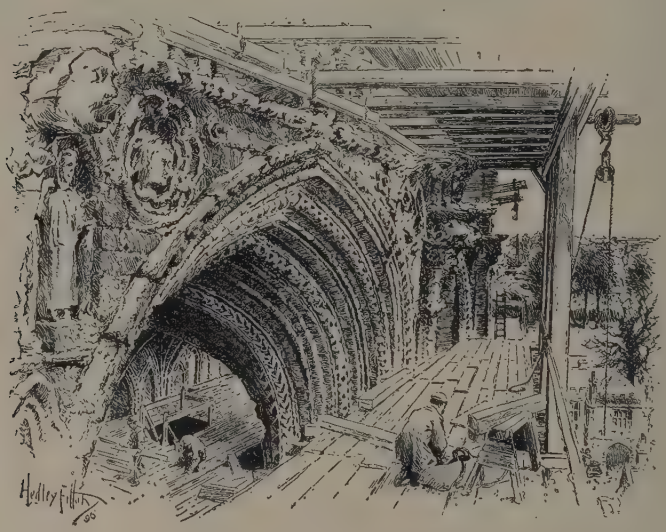

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FIG. 54

of Rouen Cathedral, France. Every line and dot contributes to the charm of the drawing. Particular notice should be taken of the technique of this drawing, as it is peculiar to this artist's work; very little outlining is done, but most of the effect is obtained by suggestion. The texture of the somewhat worn stonework is exceptionally well rendered. It will be observed that hardly any outlining is executed, the forms being obtained by the

FIG. 55 *By permission of Ernest Newton, Esq.*

careful execution of the shades and shadows, yet there is no mistaking what is the impression to be conveyed.

117. Hedley Fitton.—In Fig. 53 is shown another study in the rendering of old brick and stonework. Hedley Fitton's work is well known to lovers of black-and-white work for the vigour and energy displayed in it. In this figure, observe the almost total absence of vertical lines for expressing any feature, or change in material; these are obtained by suggestion only. Note the chimneys, window openings, plinth at bottom of building, and how cleverly the effect of old and decaying material is depicted. The wall surface to the left of the picture, which receives the full sunlight, is a study in rendering, and well illustrates how much detail should be left out. Fig. 54 is a characteristic treatment of old crumbling stonework, the texture of which is very cleverly portrayed in the rendering, and is deserving of careful study.

118. Winton Newman.—Fig. 55 is a drawing of a country house by Winton Newman. This is such an architectural perspective as would be set up to give a client an idea of the design of the building for which he had instructed his architect to prepare plans. The treatment in consequence is somewhat severe, as a great amount of detail must be shown, although effective and pleasing. The lines forming the dark shadows under the eaves and at the sides of the bays, it will be noted, follow the direction of the sun's rays, and the peculiar way in which the grass is suggested is worthy of note.

119. Raffles Davison.—A drawing of a particularly pleasing subject, by Raffles Davison, is shown in Fig. 56. It is rendered in his characteristic style, for he generally relies on grey tones to obtain his effects. The chief object in the composition, the church, is completed almost entirely in white tones, making it stand out conspicuously by contrast with the grey tones of the sky and buildings on either side. The detail is very cleverly suggested, with no feeling whatever of overcrowding.

120. W. Lee Clarke.—A drawing of Lincoln Cathedral, by W. Lee Clarke, is shown in Fig. 57, rendered in a free and open style. Note should be made of the method used to suggest the

W Lee Clarke
88.

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FIG. 56

mass of detail in the Cathedral front. When looked at from a

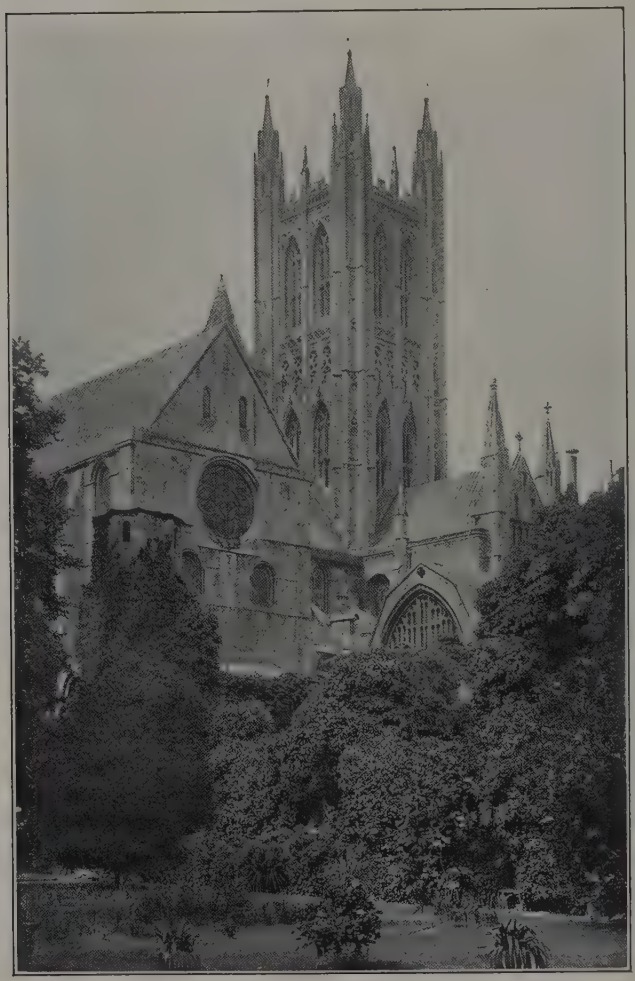


Fig. 58

reasonable distance the idea of all this detail and carving is well conveyed to the mind; but when the drawing is examined closely

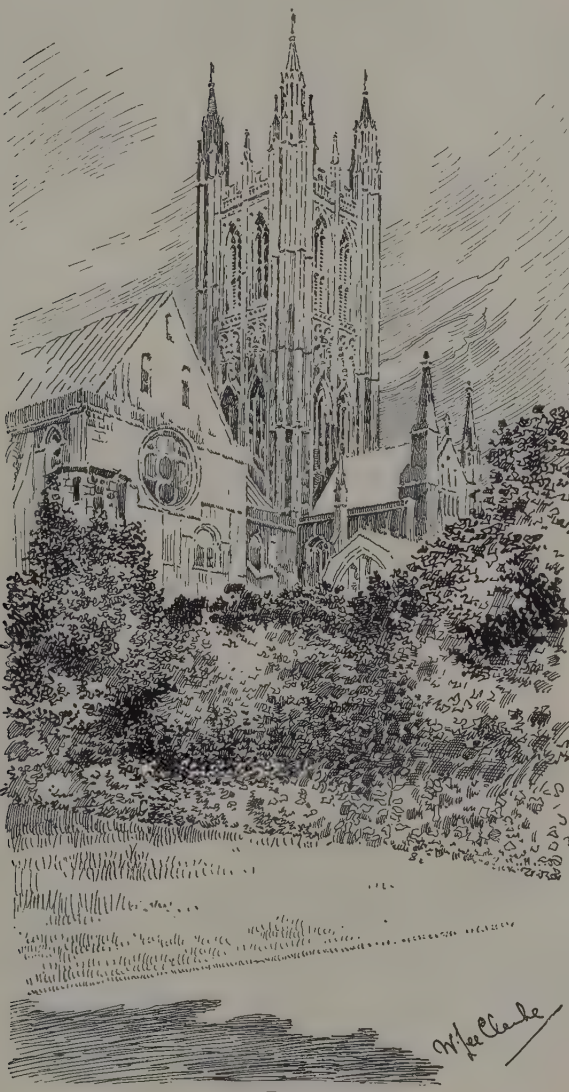


FIG. 59

it will be seen how few lines are used to gain the end desired, yet these lines are all in their right place. The foreground is rendered in a bolder manner, and it will be noticed how well the different materials are expressed, such as tiles on the roofs, brickwork of

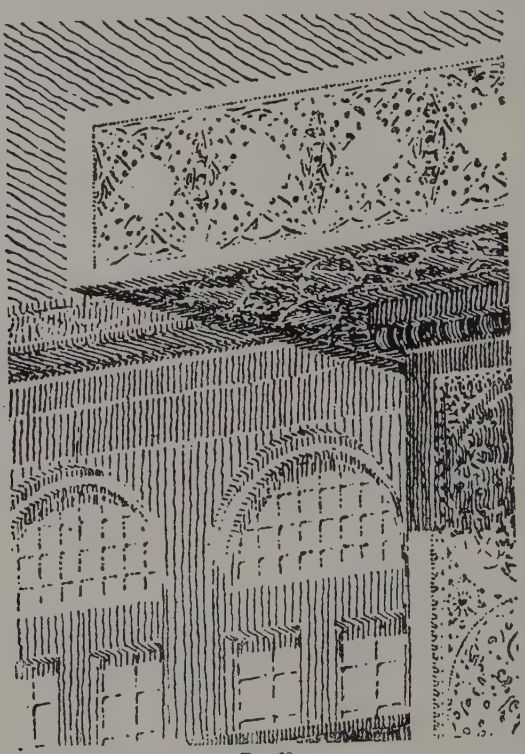


Fig. 60

the chimneys, etc. The trees introduced between the houses break up very successfully what would otherwise be a monotonous foreground. The sky has simply been indicated sufficiently to give life and reality to the picture.

121. In Fig. 58 is shown a reproduction from a photograph of the central tower of Canterbury Cathedral, and in Fig. 59 is a rendering of the same subject, by W. Lee Clarke, taken from the

photograph. The comparison between these two figures is an interesting and instructive study. The architectural portion has been simply treated, and the intricate detail of the photograph has been suggested by as few strokes as possible. The gabled building to the left of the picture, instead of being treated in dark tones as in the photograph, is left nearly white, just sufficient lines being introduced to indicate the features; the grey tones of the lower portion of the tower thus stand out well by contrast. Considerable licence has been taken with the foliage, and it will be observed that the line forming the edge of the grass plot is drawn at a greater angle than in the photograph, thus avoiding the appearance of cutting the picture off at that point. There is considerably more variety of tone in the pen drawing than in the photograph. In Fig. 60 is shown a peculiar and somewhat rare style of rendering. This is an enlarged piece of a much larger drawing of an exhibition building erected with a plaster-finished surface. It will be noticed that most of the rendering is executed with a series of practically parallel lines, differences in tone being obtained as the lines are closer together or farther apart. The plaster modelling is cleverly suggested by dotted rendering and the window divisions are shown by the slightest suggestion only.

BRUSH WORK AND WASH DRAWING

GENERAL INSTRUCTION

INTRODUCTION

122. Definition.—In architectural drawing, colour or wash work is used in various ways to represent texture or material. The term **wash work** is used because the colour is laid over the drawings in thin transparent washes that permit the pencil or ink work to show through, when desirable, after the colour is laid. These washes are divided into two general classes; namely, *flat washes* and *graded washes*. **Flat washes** are used to show sectional parts of plans or details and to indicate at the same time the material through which each section is taken. Thus,

the stone and brickwork walls of plans are coloured in to show their material. **Graded washes** are used to render finished drawings pictorial ; they are rarely used to show sections through materials, but are applied to elevations and accessories to express material and give warmth and texture to the composition.

123. In wash drawing, as in pen drawing, it is necessary to use several values. But these values should be produced directly whenever possible ; that is, one wash of the proper depth of tint should be used instead of several washes laid over one another. This direct method gives life and crispness to the drawing that it is impossible to obtain by means of a series of washes. All the principles of composition that have been studied with regard to pen-and-ink rendering apply in the same manner to wash drawing, but no attention has to be paid to the rhythm of line, inasmuch as the values are produced directly instead of by means of groups or hatchings of lines. Wash rendering, therefore, involves fewer technical difficulties than does pen-and-ink rendering. but it should not be inferred from this that wash drawing is easier than pen-and-ink drawing, for it has difficulties of its own.

124. Outlining.—In pen-and-ink work actual outlines are usually expressed by means of tints or values, but it was found necessary in several cases to indicate outlines by an ink line. In wash drawing, however, there is practically no outline, the entire form being expressed by a series of values adjacent to one another without any individual outline being expressed.

125. Brushes.—It is possible to go much further in the expression of values in wash drawing than it is with pen and ink, but it is seldom that one need use more than five values in order to express what is desired in the picture. In addition to the material used for pen-and-ink drawing, it is necessary to obtain a brush which should be used entirely for wash work and must never be used in the solid black inking that is used for filling in pen work. The brush should be about No. 6 or No. 7 and of good quality, preferably made of sable hair so that it will possess elasticity and come to a point readily. It is false economy

to buy cheap brushes; they only give poor results, especially in the hand of a novice.

126. Medium. — The medium, or material, in which the following drawings should be rendered is lamp-black, although for some monochrome rendering sepia is used, occasionally tempered with a little Vandyke brown or burnt sienna to lighten or deepen its tone. The washes for the plates to be rendered may be mixed in an ordinary saucer, or a special water-colour dish with several compartments. It is best to have two or three small dishes to contain the different washes representing different values, though after becoming experienced and skilled in the use of the brush one will be able to mix these values readily by adding more colour or more water to the solution already prepared.

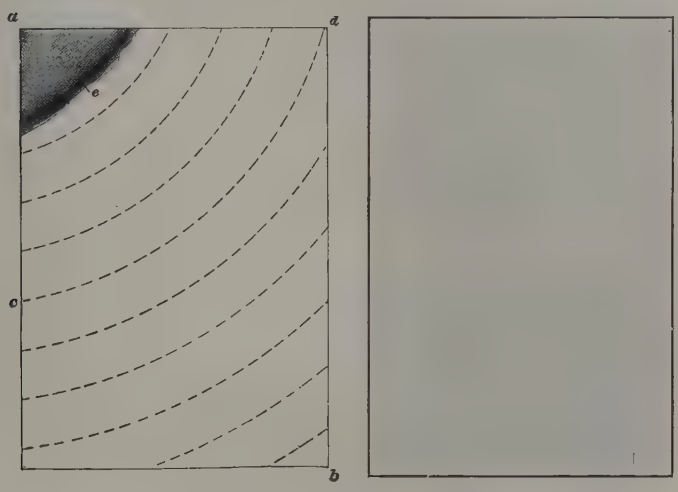
127. Paper.—Drawings should be executed on Whatman's or some other cold-pressed drawing-paper, stretched on a board. Blotting paper should be close at hand in order that the brush may be quickly dried, when occasion demands it, and a small, soft, wet sponge will be found exceedingly handy for wiping off a bad wash before it gets dry.

128. To obtain the best results on drawings where washes are required, the paper should be stretched or mounted on a board, instead of being merely fastened by drawing-pins. When doing this be sure the drawing-board is perfectly clean and absolutely free from greasy substance. Lay the paper right side up on the board. (The *right* side of any water-marked paper is that which is toward you when you can read the water mark in its proper sequence of letters.) Turn up an edge about $\frac{1}{2}$ inch wide, all round the four sides of the paper, so that the paper resembles a large flat dish or tray with a raised edge. Now reverse the paper so that the wrong side will be up, the paper resting with its folded edges (reversed) touching the board. Apply strong paste, with a stiff brush, to this folded edge, so that it is on the " wrong " side of the paper, and then go quickly over the paper with a wet sponge, taking care not to touch the paste. Then reverse the paper so that the right

side will be up, and smooth it from the centre toward the edges with a damp sponge, pressing down the pasted edges until they are sufficiently dry to adhere to the board all round. If the edge of the paper does not adhere tightly at certain places, when the paste is still moist rub it tightly into place with a flat paper knife or with the back of the finger nail. Lay the board flat and give the paper time to dry by evaporation. Do not try to hurry it by placing it in the heat, for this will probably cause the paste to crack loose from the drawing-board. The paper will at first look wrinkled and spoilt, but will soon dry and be perfectly smooth and ready for working upon. When the drawing is finished the paper can quite easily be taken from the board by cutting through it with a sharp knife just inside the pasted border.

129. Before the first drawing plate is begun, the method of laying a flat and graded wash should be carefully studied. A large quantity of colour should be mixed so as to make a liberal amount of wash, as it is nearly impossible to mix up an extra quantity to exactly the shade, when the quantity made up first becomes exhausted. For the purpose of rendering the following exercises moisten the pan, or part of the contents of a tube, of lamp-black, and mix a few brushfuls with water in a saucer ; stir this up well with the brush and test it on a piece of scrap paper, allowing it to dry before any attempt is made to wash in the drawings, as its exact tone cannot be seen until it is dry. It is always better to keep washes too light rather than too dark, as evenness can always better be secured in a light wash than in a dark one, and it is easier to go over a wash that is too light to make it of the required depth than it is to sponge out a wash that is too dark. In applying the wash the colour in the saucer should be constantly stirred, as the water and pigment are apt to separate, thereby making the wash uneven in places. While in general practice it is better to mix the colour to the exact tone required and lay it on the paper, wash drawings may be varied by laying a new wash over the old one after the latter has dried, thereby deepening its tone, as will be observed in these exercises.

130. Flat Washes.—For the purpose of practice, and to become able to lay flat and graded washes properly, the following exercises should be carefully washed. These need not be sent in to the Schools for correction. Do not commence the drawing plates until confident that these exercises can be rendered correctly. In Fig. 61 (*a*) is shown the method to be adopted in laying a flat wash. On a sheet of drawing-paper previously pasted down to a board, draw a rectangle in pencil with sides of 5 inches by $3\frac{1}{2}$ inches. Take up as much colour as possible



(*a*) FIG. 61 (*b*)

on the No. 6 brush and apply it to the upper left-hand corner of the rectangle, as shown. Care should be exercised not to let the wash extend over the edges, and to have sufficient colour to secure a liberal pool at the corner of the rectangle. Tilt the board so that with the aid of the brush the colour may be led to flow downwards toward the lower right-hand corner, where it should be conducted in a series of curved strokes, as shown by the dotted lines. As each stroke is made, the brush should be redipped in the colour and the wash carried down with a liberal supply of fluid on its lower edge.

131. If the brush is not large enough to carry the entire pool across from the side to the corner, as from *c* to *d*, it should be carried as far as possible and redipped in the saucer ; under no circumstances must the lower edge of this wash be allowed to become even partially dry as it proceeds across the rectangle, for it will then leave a line. When the corner *b* is reached, the surplus colour may be taken up with a dry brush, or with one from which the colour has been extracted by drawing it across a blotter. Repeated applications of the brush to the blotter and to the corner of the rectangle will remove all the surplus fluid and should leave the entire wash perfectly even and clean, as shown in Fig. 61 (*b*). As the laying of flat washes of this character is a matter of practice more than skill, this exercise should be repeated several times.

132. In washing in Fig. 62, a rectangle of similar dimensions to that described for Fig. 61 should be drawn in pencil, and should be subdivided, by light pencil lines, into five equal bands or strips, as shown at *a*, *b*, *c*, *d*, and *e*. The graded washes are laid by repetition, that is, all five rectangles are first washed over with a plain wash, identically the same as in Fig. 61 (*a*). When this is thoroughly dry, a second wash is laid over the rectangle, with the exception of the lower subdivision *a* as shown ; when this is dry a third wash is laid, omitting two subdivisions *a* and *b*, as shown. In this manner the figure is completed, resulting in one wash at *a*, two at *b*, three at *c*, etc.

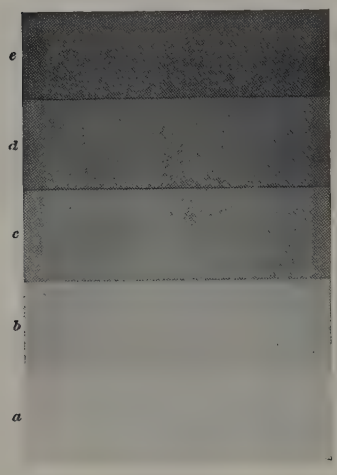


Fig. 62

133. In Fig. 63 is shown a similar exercise to that given in Fig. 61, but slightly more difficult. A rectangle of

similar dimensions is drawn, but on one end of it is described a semicircle with diameter *a b* equal to the end of the rectangle, that is, $3\frac{1}{2}$ inches. Divide the circumference of this semicircle into ten equal parts, and through the points of division draw vertical lines the full length of the rectangle, as shown. This will divide the rectangle into ten bands of varying widths in proportion to the receding arcs of the semicircle. The graded washes are laid by repetition as before; that is, all ten divisions are first washed over with a plain wash, identically the same as in Fig. 61 (*b*). In Fig. 63, the washes are graded in tone, thus presenting the appearance of a rounded or prismatic surface. The sections of the rectangle being divided by projectors from the semicircle, the appearance of the curve is very marked, and to enhance this effect the washes are laid so that they grade in each direction from the lightest wash, which is on the third rectangle from the left, but on the dark side of the rectangle the heaviest wash is found at *b*, where there are eight applications, while to the left of it there is one less as each subdivision is passed, until the lightest is reached, third band from the left side *a*. The next one will have two washes, and the one at *a* will have three.

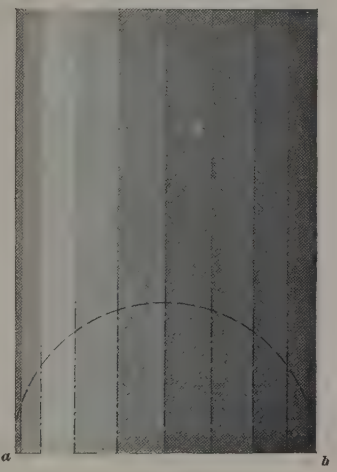


FIG. 63

134. Graded Washes.—In Fig. 64 is shown a rectangle similar in size to those last described, but with two pencil lines running diagonally across it, quite close together. The execution of this figure is similar in effect to Figs. 61 to 63, but is much more difficult in application. Graded washes are laid by first applying the top tone at the upper edge of one of the triangles

with the brush charged with very dark colour. This wash is carried down about one-fourth the depth of the triangle from the edge, that is, the edge that is being worked from. The pool at the bottom of the wash remains as usual while the tip of the brush is redipped in clear water and added to the lower edge of this pool so as to dilute it, and the wash is carried somewhat farther. Again the brush is dipped in water and the diluted wash is carried still farther until the bottom of the triangle is reached and the tone is almost clear water. In this way, the colour grades from dark to light. The lower half of Fig. 64 is similar in appearance but reverse in effect. Here the wash is applied in its lightest tone first, and additional colour is added to it to deepen the tone as the pool is carried over the plate. When the lower side is reached, the darkest tone is applied. Precisely similar results can be obtained by either of these methods, but it is occasionally more convenient to use one than the other. The ability to lay graded washes of this character gives confidence in oneself and an understanding of the possibilities of this class of work.

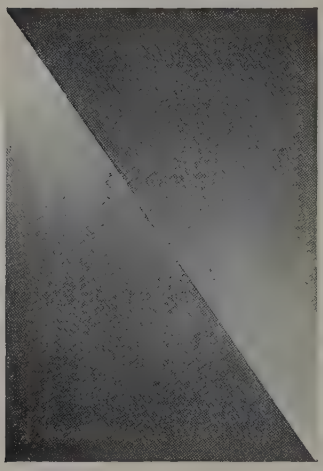


Fig. 64

135. Having executed the exercises contained in Figs. 61 to 64 several times, the first drawing plate may be drawn and sent in to the Schools for criticism. It is always advisable, if time permits, to wash in a copy of the plate before the finished drawing on the outline plate is commenced, as by doing the work twice there is more likelihood that the plate forwarded for criticism is well done. After having carefully pasted down a sheet of drawing-paper, lay it away to dry. Then

WASHED ELEVATION

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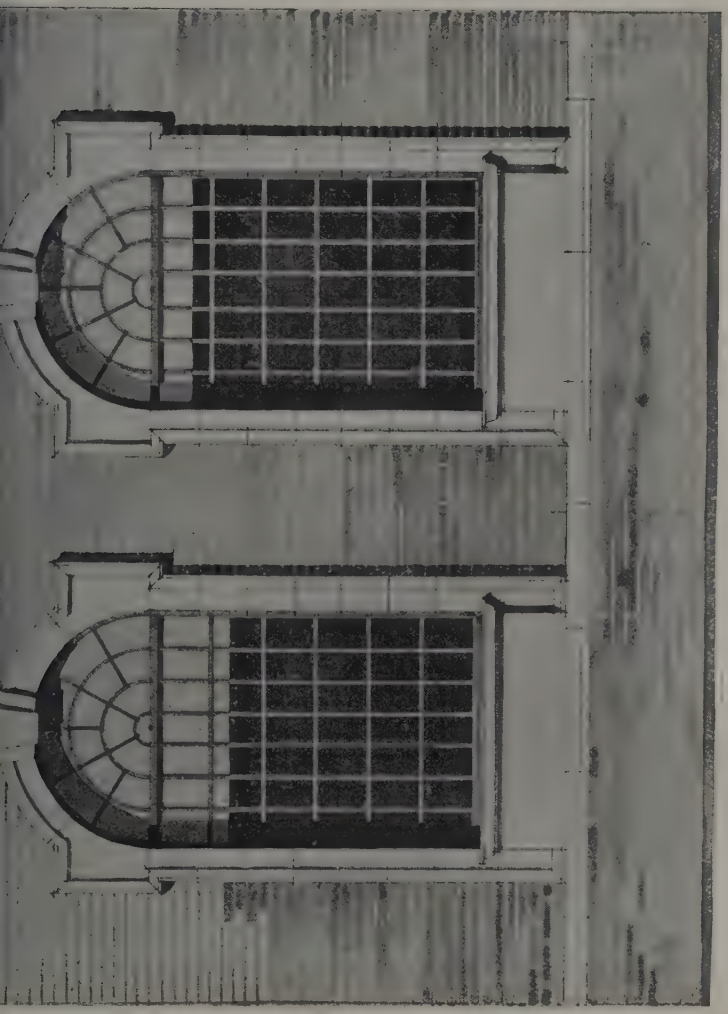

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trace very carefully in pencil the outlines and detail of the outline sheet. These should be transferred to their proper places on the mounted paper, having first ascertained that this is perfectly dry, and, if necessary, the transfer may be lined in, in pencil. The straight lines may be executed with the T square and set-square and the curves put in with compasses. This process of tracing and transferring the outline is advised because, when washes are to be applied to the paper, the surface must be perfectly smooth and even, and if much rubbing is done, in order to correct the drawing, the washes will not flow evenly.

DRAWING PLATE, TITLE: WASHED ELEVATION

136. This plate indicates a simple treatment in flat tones of an architect's detail drawing, and contains various values, including light grey and black. No attempt has been made to render actual light values, except where the small patches indicate where the strongest light falls on the objects. Observe how much can be expressed by the simple suggestion of these high lights, and study their positions on objects in order that they may be put in their proper places. The success in rendering this figure depends as much on the accuracy in placing the high lights and shadows as on the smoothness of the washes; truth in values can be obtained only by painstaking care, in experimenting with each wash and matching it carefully with the scale of value desired. Smooth washes can be obtained only when the wash is laid rather quickly and spread over the surface evenly before any portion has had an opportunity to dry. The outline sheet should be carefully pasted down upon a drawing-board, as before described, and when quite dry the board should be held in a slanting position toward the worker, and a light wash begun in the upper left-hand corner and carried down from left to right over the whole washed surface. When the wash is completed and the surplus colour has reached the lower right-hand corner, the brush should be dried on the blotter and the point applied to the wash to absorb the superfluous moisture. Care must be taken on this figure that one wash is thoroughly dry

before the next one is laid over it, otherwise they may run together.

137. A darker wash should now be laid over the first to give the shade on the brickwork which is shown darker toward the lower right-hand side of the plate. Let the light wash show through to give the effect of horizontal brick joints, as shown. The dark window panes, where the blinds are not drawn, should next be washed in, care being taken not to get the surface too even in tone, for if this is done much of the life of the drawing will be lost. Light specks should be left here and there, as shown, and small patches of darker colour should be inserted to give realism to the drawing. The darker tones on the top members of the cornice can be completed, as also those on the woodwork of the windows and window sills. The deep shadows from the windows and cornice should be put in last of all ; care should be taken that the shadow from the cornice is darker when cast upon the brickwork than when cast on the stonework. The only work remaining is the insertion of the darker touches on the brickwork and the lining in of the brick joints where they occur in the upper left-hand portion of the plate. The border line should be carefully drawn in with a fairly dry brush charged with dark colour. The title should then be carefully drawn at the bottom of the plate, the date placed in the lower left-hand corner, and the name and class letters and number in the lower right-hand corner, and the plate forwarded for criticism. Regarding size of plates after trimming, see Art. **60.**

DRAWING PLATE, TITLE: PIER AND BALUSTRADE

138. The problem in this plate is more complicated than that in the last one because there are more variations in light and shade in it, as in this one the shades are graded and vignetted into one another in places, while the drawing plate entitled Washed Elevation consisted entirely of flat washes. Having pasted down the outline sheet, and being satisfied that the palettes and brushes are quite clean, mix up a very light wash

PIER AND BALUSTRADE

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of colour and lay this in one flat even wash over the whole of the rendered portion of the composition. It will be noticed that no portion of the stonework is left as absolutely white paper, as all stone, however bright may be the sunlight in which it is situated, has a certain grey tone, indicative of its texture. When this first light wash is quite dry, another wash of about the same depth should be laid over the whole surface with the exception of those portions in highest light, such as the sides of the balusters and certain portions on the right-hand side of the pier where the sunlight particularly strikes them. The left-hand side of the pier is of a slightly darker shade than the highest lights on the right-hand side.

139. When this second wash is dry, the top stone of the pier should be washed in, as also the portions of the balustrade and skirting that are of about the same tone, care being taken to leave the lighter specks shown, to give life to the drawing. These spots or specks should be left in a careless manner, and should not appear as if they had been left intentionally. The darker washes on the balusters are then put in, and where shown must be carefully graded to give the idea of the rounded moulding to same ; after this the dark portion on the other side of the steps at the left-hand side of the pier may be finished. The paving in the foreground is perhaps more difficult to wash than any other portion of the composition, but with care and close copying of the original a good effect can be obtained. Owing to the fact that the paving would probably be worn and uneven, flat washes are not used here, but graded washes take their place, according to the extent to which the paving stones are worn or out of level, and catch the light or not. The effect can quite well be obtained if, when washing in the paving stones, a little darker colour is added to the plain wash, just before it is dry, in the places where darker patches occur. The only work now necessary to complete the plate is the washing in of the shadows, which should be very carefully done. Flat washes must not be used here, as in nearly every shadow the texture of the material on which it is thrown shows through it, and consequently if there is any unevenness in the texture of the stone it should be shown through the shadow.

Take, for instance, the shadow under the cap of the pier; it will be seen how uneven this is, but it must be acknowledged that it looks rather realistic; therefore the attempt should be made to imitate it. After washing in the border line, carefully print in the title upon the bottom of the plate; place the date in the lower left-hand corner, and the name, class letters, and number in the lower right-hand corner, cut the drawing from the board, and forward the plate for criticism.

DRAWING PLATE, TITLE: OLD HOUSES

140. This is much more difficult than the two preceding plates, but with care and a close study of the original it can be quite successfully completed. As before, carefully paste down the outline sheet, and proceed with the lightest washes first, so that general washes which go over almost the whole surface of the composition may be completed before the detail is commenced. It will be noticed that the high lights are very marked in places; these should be left as white paper, without any wash on at all. If, however, some of the bright lights have been washed over, they can be brought back by washing Chinese white over the surface, but this should be used very sparingly, as in the hands of a novice it often does more harm than good. Having carefully washed in the general light washes and the darker washes on the roofs and left-hand side of the houses in the picture, the darker shades and shadows that show the detail may be added. The indication of tiles on the roofs, the window bars and panes, and the timber to the shop front and gables must be proceeded with; as the detail is small this work should be executed with a somewhat drier brush. On no account must the brush be allowed to become so dry that the surface of the paper is covered with difficulty. Sufficient colour must always be in the brush to allow the wash to flow well on the paper. The sky should be finished, using the colour very wet indeed, so that there may be no dry edges to the washes, and then the darker shadows of the buildings should be washed in, care being taken not to get them

OLD HOUSES

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too dark, or they will lose their transparent effect, which is so desirable with every shadow. Notice, for instance, how transparent is the shadow under the projecting awning over the shop window.

141. Perhaps the most difficult portion of this composition is the figures contained in it, but without them the buildings would not have the air of reality that they now have. If care is taken in washing in these figures, and no more detail is inserted than is shown in the original, they will appear quite real and life-like, but if the copy is not followed carefully they will appear wooden and spoil the whole composition. It only remains now for the finishing touches to be applied and the shadow in the foreground, probably cast from an adjoining building, to be washed in and the drawing will be completed. Before taking the drawing from the board, look very carefully over it side by side with the original and see if anything has been omitted ; also whether it could be improved in any way by further working upon it ; if not, carefully draw the border line, and print in the title at the bottom of plate. Place the date in the lower left-hand corner, and the name, class letters, and number in the lower right-hand corner, cut the drawing from the board, and send it to the Schools for criticism.

DRAWING FROM LIFE

DRAWING FROM THE HUMAN FIGURE

FIRST PRINCIPLES AND MATERIALS USED

INTRODUCTION

1. Difference Between Life and Cast Drawing. — Finished drawings from a living model should not be undertaken without first having considerable practice in drawing from the plaster cast. Sketches from the figure that require no longer than 15 or 20 minutes' time to complete, may be made with advantage, if full and proper attention is given to the direction of the lines and the position of the masses. But the forms of the different parts of the body as they appear in the plaster cast should have been carefully studied before the attempt is made to draw from the living model. No matter how steady it may be, the living model will unconsciously change its posture under growing fatigue, and unless one is familiar with form and construction, one part of the figure will be drawn as it first appears and another part as it appears after the model has sagged from fatigue. In drawing from the cast, the main forms and proportions should be closely studied in order that the main lines of the human form may become impressed on the mind. The whole figure, when drawing from life, can then be rapidly sketched in before exhaustion has set in, and any errors in the work, owing to changes in the pose of the model, can be afterwards detected and eliminated.

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2. Posing the Model.—For general practice it is usually better to have the model elevated somewhat above the eye. To accomplish this the model should stand on a box or platform, while the effect of elevation may be still further increased by the student working in a sitting posture as low as possible. A convenient easel can be made by inverting an ordinary kitchen chair, as shown in Fig. 1, which is a photograph of a life class, showing the usual method of working. The drawing-board can thus be laid at a convenient angle on the rounds of the chair, and at the same time the model can be seen plainly.

MATERIALS USED

3. Crayons and Papers.—Drawings from the figure, as from the cast, may be executed in charcoal or crayon on white or tinted charcoal paper, many brands of which can be obtained. Two popular brands, the Lalanne and the Michelet, are greatly used. Incorrect lines may be erased by means of a piece of fresh bread; this leaves the surface of the paper in quite as good condition as before the erasure, whereas rubber roughens it. A piece of string, with a weight on the end of it to serve as a plumb-line, is very serviceable in noting the points that fall beneath one another in the figure. It may be held before the eye, and various points fixed from which to work.

4. Stumps.—Where a fine finish is required to the drawing, pulverized crayon is used, and applied with small paper **stumps,** Fig. 2, which consist of rolls of cartridge paper of various proportions from the size of an ordinary brush handle to the thickness of the forefinger. From this size, however, to the largest ones they are usually made of chamois leather. For charcoal work it is best not to use the stump, as the charcoal should be used only for blocking out and general modelling, but for *close modelling*, as delicate finishing is termed, the lines may be blended into tints by touching them with the stump, or it may be dipped in the pulverized crayon as a brush would be dipped in colour and the tints applied directly with it. In working, a small piece of sandpaper is necessary to keep the crayon pointed, and an easel on which the board can rest.

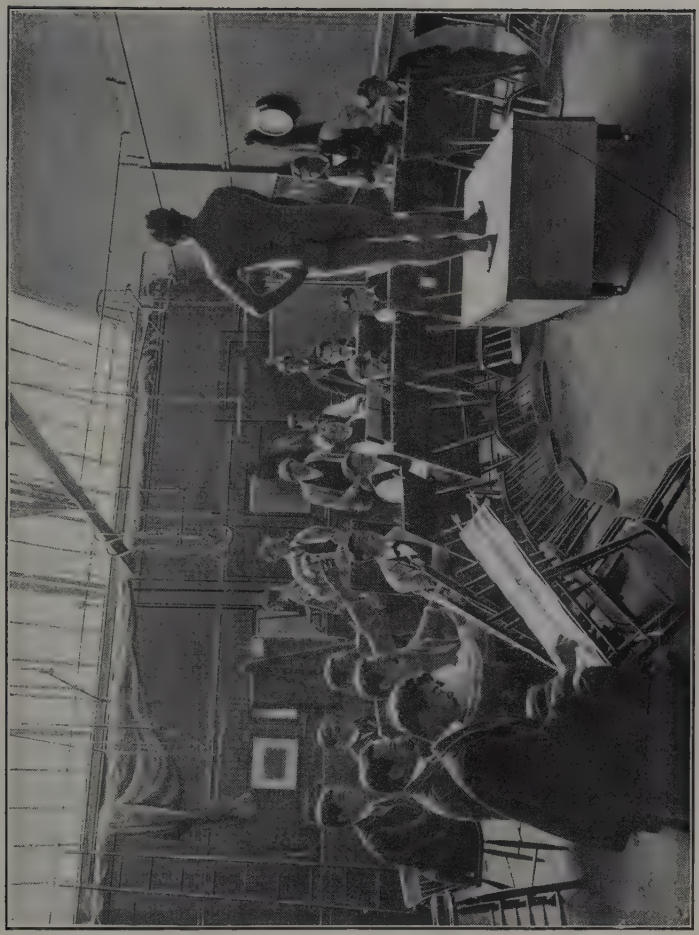

FIG. 1

OUTLINING THE FIGURE

5. Blocking In.—The first outlining of the general form of the figure is called **blocking in.** The size of the drawing should be such that it will cover the whole length of the paper. The reason for this is that when it is required to make compositions either for decorative work or for illustration, each figure must fill a certain space, so that by becoming accustomed to proportioning the size of the drawing to the space it is to fill, no difficulty will be met with in future work.

6. Unit of Measurement.—The head, from the chin to the crown, is commonly used as a unit of measurement, each figure being considered as so many heads high. A pencil held upright at arm's length may be used in estimating the proportions and distances for different parts of the figure, after the manner

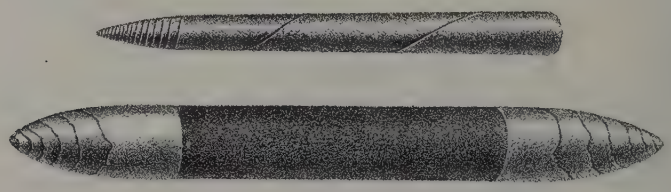

FIG. 2

described in *Drawing From the Cast.* In this way it is possible to fix almost exactly the position of each detail of the figure before the main structural lines are boldly drawn in.

Besides finding the lengths of the various parts, it is also necessary to find the positions of important points relative to a vertical line passing through any convenient point on the torso. This imaginary vertical line is generally represented by a plumb-line held in the left hand, as shown in Fig. 3. When drawing a figure that represents the body in action a plumb-line is of great assistance. In such cases it is not only important to find those points that fall directly below one another, but also to ascertain the distance between a vertical, laid through some prominent point on the torso, and important points situated at either side of it. For instance, referring to Fig. 3, if the

Fig. 3

plumb-line is held so as to be tangential to the rear side of the shoulder, it will be possible to ascertain the positions of the following points relative to the imaginary vertical line indicated by the plumb-line: (*a*) The position of the rear side of the head and its inclination; (*b*) the position of the small of the back; (*c*) what portion of the thigh will come in front of the vertical; (*d*) the distance of the knee behind the line; (*e*) the positions of the left and the right foot; (*f*) the main lines of the left arm, and possibly the position of the right hand. After these points have been fixed the plumb-line may be shifted and the positions of additional points fixed, if necessary. With the plumb-line to fix points that fall beneath one another, and the pencil as a scale for measuring, all the main features can readily be drawn in with exactness.

The first measurement to take is the height of the head, and with that as a unit, measure the number of heads in length each portion of the body appears to be. The standard human figure is assumed to be eight heads high; that is, a man standing 6 feet in height should have a head very close to 9 inches in height. In Fig. 5 is shown a standing male figure where the height is from *d* to *c*. If *d c* is divided into eight equal parts it will be seen that the first division *c f* just takes in the portion from the crown of the head to the chin; therefore this figure is just eight heads high. The female head, however, is larger in proportion to the height than the male, and the average woman stands seven and one-half heads high. However, various exceptions to these measurements are found in everyday practice.

7. Action.—In viewing the figure, the first thing to consider is the **action,** by which is meant the general trend of the main lines. By these main lines alone it is possible to express the entire intention and purpose of the figure. It can readily be seen that a man running leans forwards, that a man pulling on a rope and bracing himself leans backwards, and that a man standing in conversation usually rests on one foot so that the main lines of the body are perpendicular. The direction of these lines expresses the action of the figure and should always be considered first. This, combined with the proportion of the

main forms, gives a solid ground on which to proceed with the work.

8. The lines indicating action and proportion should be marked by definite points of start and finish, and should be drawn in boldly without any attempt to follow closely the general contour. By *definite points* are meant the shoulders, hips, knees, ankles, etc., which, after their positions have been determined by means of the pencil measurement lines, can be drawn from them in bold sweeps giving the fundamental lines of the figure. These lines will give the action ; the lines of proportion can be worked over them. By combining these the first necessary steps in the drawing of a well-constructed figure are taken. In drawing the arm, work from the point of the shoulder to the elbow, from the elbow to the wrist, and from the wrist to the tips of the fingers ; this will give to each form its proper allowance of space and distance, and the subtle curvature of line that must afterwards be expressed is built up on it, but should never be attempted until the first outline drawing is satisfactory and as nearly correct as possible.

9. While great stress is laid on these details in drawing from life, they are equally important in the drawing of any object ; but as the human figure is the most difficult of all objects to represent, no detail of these rules can possibly be overlooked. All estimates of proportion are more or less dependent on the point of view from which the object is seen ; a figure, though it measure eight heads in height, would appear taller if the eye of the worker were below it, as would be the case if the model were on a platform. Thus, a drawing should always be made to show the figure as it appears under the influences of different circumstances.

10. Median Line. — The number of heads in height being established, a central point of the figure is next to be found. If the view happens to be full front or nearly so, a **median, or central, line** can be drawn from the pit of the throat and continued downwards between the breasts, to the navel ; this will denote the main trend of the trunk and be of great help in finding the proportion that the shoulders, breasts, arms, and sides bear

to each other. It is always best to draw the figure round a strong central construction line, as this is much easier than attempting to draw an outline and filling in the other portions afterwards.

FORESHORTENING

11. Foreshortening. — To foreshorten an object in drawing is to shorten parts of its representation so as to give the proper impression concerning its form and proportions, or to represent it in such a manner as to convey the impression of the entire length of an object that points toward the spectator. It is a well-known fact that in looking squarely at the surface of a circle every point of it is equally distant from the centre, but if it is inclined from the spectator its perspective becomes an ellipse that varies in width according to the angle of inclination. If the position of an object is such as to cause one or more of its dimensions to be reduced in length, a view of such object is said to show it **foreshortened.** An ellipse drawn or painted to represent a wheel or other circular form in perspective conveys to the mind the idea of a circle, because the eye is accustomed to seeing circles in that shape when they occupy that supposed position.

Foreshortening is also expressed by means of a change in size, distant and near objects being represented as differing in size according to the varying distances from the eye. It should be borne in mind, however, that the relative difference in size between two objects, one more distant than the other, is dependent not alone on the distance that they are apart, but also on the relative distance that each is from the eye. For instance, a circle 2 feet in diameter and 20 feet from the eye will appear only one-fourth the area of a circle 2 feet in diameter and 10 feet from the eye. In this case the circles are 10 feet apart. If, however, they are moved backwards a distance of 100 feet and still maintained at a distance of 10 feet apart, one of them being 110 feet from the eye and the other 120, their apparent difference in size will be very slight, as their relative distances from the eye will not differ so widely. In the same way, when drawing the human figure, distant portions of the figure, though they

appear smaller on account of their remoteness from the eye, must not be exaggerated in their diminution; otherwise, the figure will possess a distorted appearance unless viewed from exactly the same point from which it was drawn.

12. In the foreshortening of the human head that results when it is looked at from below, the appearance of the chin will be the same as that produced when the head is thrown sharply backwards and viewed from a point directly in front of the figure. This is illustrated in Fig. 6. The space between the eyebrows and the lids is brought into full view, because none of it is lost in perspective as is the case when the eyes of the model and the eyes of the observer are on the same level. Here, also, the nostrils and the triangular mass of shadow beneath them suggest the general formation of the base of the nose. The upper lip is observable at its greatest thickness, while the lower lip appears thinner than it would if the eye were on a level with those of the model. The surface beneath the jaw is also distinctly seen, and the chin is more in the foreground than any other part of the face. The ear is also dropped below the level of the eye. If the head and face were geometrical in form, like a cube or cylinder, their foreshortening could be accomplished with mathematical precision by means of perspective, but the surfaces of the head and face are complex, and in consequence cannot be governed by any simple rule of perspective. The eye must be the sole judge.

13. When the head is observed in three-quarter view and from a point below the model, the features, or details of the features, nearer the eye of the observer appear higher than those that are farther removed; and, on the contrary, when the three-quarter view of the head is seen from a point above the model the features, or parts of the features, nearer the eye appear lower than those that are farther removed.

In drawing a head that is much foreshortened, it is well to grasp points of prominence on which to build the construction, such as the temples, cheek bones, point of the nose, chin, and ears. The line from one temple to the other will suggest the main direction of the forehead, from the temple to the top of

the ear another direction, from the cheek bones to the chin and the chin to the bottom of the ear still other directions. When the head is seen from a point far above the model, the whole top of the model's head is brought into view ; the eyes are lost beneath the brows, their position being suggested only by shadows, and the lower part of the nose overhangs the upper lip, throwing it into shadow. From this standpoint the upper lip appears to be very thin and the under lip is exposed to view at its full thickness. The under surface of the jaw is completely obscured and the position of the ear is very high. The position of every feature, or part of feature, is exactly the reverse of what it would have been if seen from a very low point of view.

MODELLING

14. The term **modelling,** as applied to drawing and painting, refers to the indication of form and solidity through the medium of light and shade. A well-constructed figure, even though drawn only in outline, will suggest solidity, but modelling makes it a tangible mass. If a figure is placed in strong light coming from one direction, the light and shade will resolve themselves into well-defined planes, while the margins of the shadows will seem to have a definite outline, darker in some places than the body of the shadow itself. Therefore *planes of light* and *shade* are convenient terms that may be used whenever reference is made to these details.

15. It may be assumed that the body is composed of a number of flat or flattened surfaces joined together to cover the general mass in the same manner as the block head and the block hand. The blending of the shadows where these planes meet gives the rotundity and completes the modelling of the figure. The simple effects of light and shade in the block head and hand are perfectly applicable here, and though the shadows may not be sharply defined they may be considered so and blended off afterwards. In drawing from the life, the eye must search carefully for half tones of shadow that are not seen in the cast, in order to give them their proper value.

16. In drawing from life, the first thought should be to search for the definite margins of the main shadows; sharply defined shadows that are found in some portions of the margins are lost in others, and in other places the margins of the shadows appear to blend with the lights forming the half tones. Careful search, however, will disclose the fact that the half tone itself has a definite margin. Looking at the figure as a whole, a search should be made for three main varieties of tone: the full light, the full shadow, and the half tone. With practice, it is possible to distinguish and draw the margins of these three tones accurately and then to render the tones themselves. Subsequently, the effect of solidity is easily produced, because the blending of one tone with another is a very simple matter. There is a danger, however, that even when these three tones are correctly drawn, there will be a certain harshness and want of sympathy in the treatment of the shadows. As these tones have been worked in mechanically, the figure lacks the softness and lifelike appearance that it possesses in nature. These shadows therefore must be given that infinite variety that they really possess. Searching the planes once more, places on the margin of the shadows are found where the definition is entirely lost, the shadow melting entirely into the light; in other places, the definition is accented by a greater depth of tone and a more distinct edge. This search for variety in the quality of the shadow should be made after the main tones are rendered, because it is very hard to discern and is liable to detract from the character of the work if an attempt is made to render them as the general modelling proceeds.

ANALYTIC STUDY OF THE HUMAN FIGURE

THE HEAD

17. **Profile View.**—Viewed in profile, the head may be enclosed in a perfect square and the face divided into thirds from the roots of the hair to the chin, as shown in Fig. 4. These thirds may be marked: *1*, from the roots of the hair to the brows; *2*, from the brows to the base of the nose; and *3*, from the base

of the nose to the bottom of the chin. The distance from the crown of the head to the roots of the hair is about one-fifth the height of the head. These measurements vary with each individual and cannot be taken absolutely, but for general drawing may be considered as a basis for construction.

In Fig. 5, a front view of the male figure is shown, on which these measurements of the face are applied. The face from the roots of the hair on the level at *g* to the chin at *f* is seen to be divided into three equal divisions. That at *h* passes through the brows and the one at *i* through the base of the nose. The distance *g c* from the crown of the head to the roots of the hair will be found to be one-fifth the height of the head.

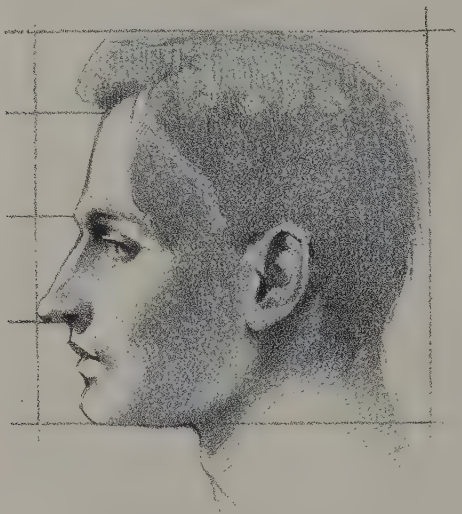

Fig. 4

18. Full View. In the front, or full-face, view, the head may be considered as about five eyes in width, the space between the eyes and on each side occupying a distance about equal to the length of the eye itself, as shown in Fig. 5. If a cross-section of the head were made at the height of the eyebrows, it would be nearly oval in shape with the fullness in the back, as illustrated by the inside of the brim of a hat. If a piece of tape is tied round the head at the line of the brows, so that it touches the tip of the ears, it will describe an oval and form a means of fixing certain features of the face when the head is thrown backwards or forwards so as to change the relative position of the features, as shown in Fig. 6. Thus, in drawing the head from any standpoint,

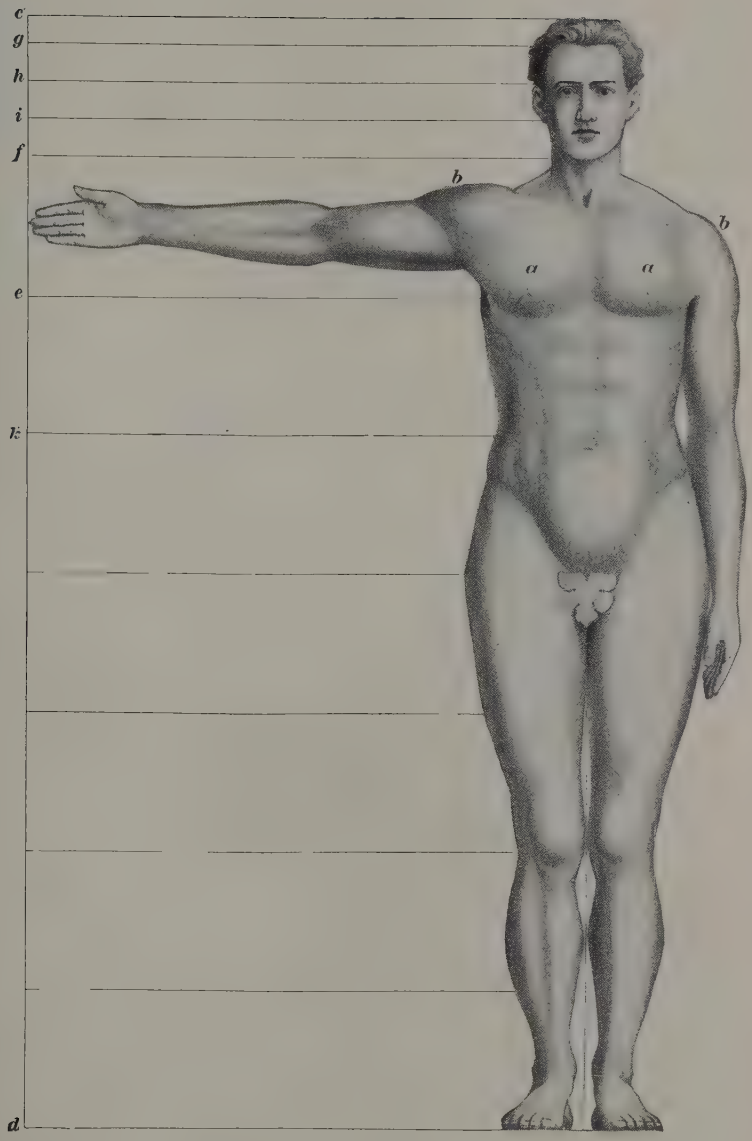

FIG. 5

whether the eye of the observer is far beneath, looking up to the model, or above, looking down, the change in position of the brows and tips of the ears will always be indicated by the altered position of this ovally bent strip, or tape, so that their positions can always be accurately determined. However, the

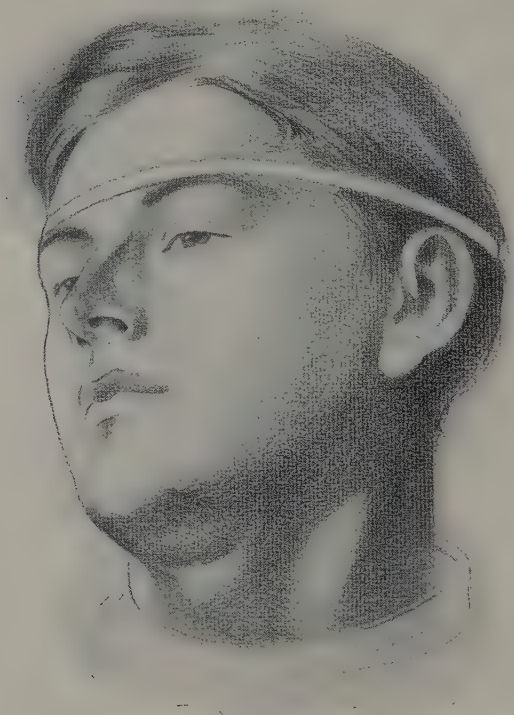

Fig. 6

human head is so varied in its proportions that such means as this tape, a plumb-line, and others, can be depended on only to a limited extent. It must in most cases be drawn as seen, irrespective of any set rules, for adherence to them is likely to be productive of a stock face or figure that soon becomes devoid of interest and novelty.

THE NECK AND SHOULDERS

19. After drawing in the head, the neck and shoulders must be considered; a line from the point of one shoulder to the point of the other gives the general direction. Where the neck joins the back of the head it rises much higher than at its junction with the fleshy part of the face under the jaw. The junction of the neck with the back at the line of the shoulders is correspondingly higher than its junction at the pit of the throat. Thus, if lines are drawn across the neck, from its points of junction in the back to its points of junction in the front part of the body, such lines will have a downward oblique direction, as shown in Fig. 7. The shoulders, which in the common acceptance of the word include all the space from the neck to the muscle that caps the end of the bone of the upper arm, usually termed the humerus, rise above the clavicles, or collar bones, and form a sort of muscular defence for them against injury.

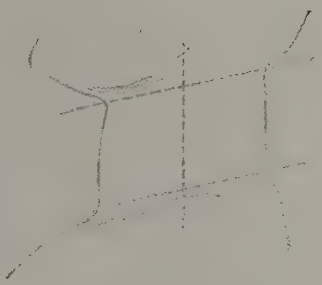

FIG. 7

THE MUSCLES OF THE BREAST AND ABDOMEN

20. The Pectoral Muscles.—The two rather massive prominences on the breast of the male figure shown at *a*, *a*, Fig. 5, and *b*, Fig. 8, are the pectoral muscles. They are separated by a slight indentation or hollow extending from the pit of the throat downwards. In repose, their surface is unbroken by any muscular markings, but under strong action they are well defined. Their contour is indicated by the shape of the shadows that fall on them. The positions of the various forms on the chest are very readily determined by the relative positions of the nipples, which in the standard male figure are one head below the chin, as shown by the line through *e* in Fig. 5.

21. Muscles of the Abdomen.—The muscles of the abdomen are situated beneath the massive pectoral muscles, on each side of a perpendicular line drawn from a point midway between the breasts, to a point centrally between the knees when the figure is standing erect as shown in Fig. 5. They are somewhat indistinct when in repose, and are frequently obliterated entirely by an excess of fat. In the thin or muscular figure they are sharply defined when in action and appear as three separate masses on each side of the centre line above mentioned. Their lower boundary line is indicated by the line through *k* produced.

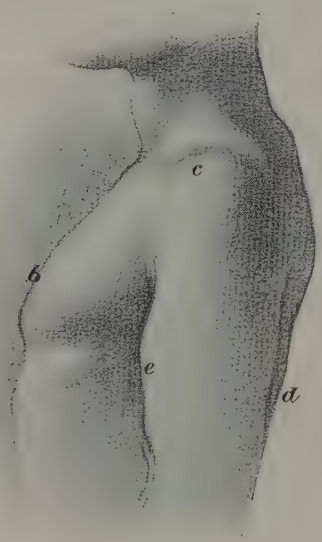

Fig. 8

22. The Breasts. — In drawing the breasts of a female figure, the forms and shadows are very subtle. In the front view, in which they cannot be indicated by definite outlines, the expression of their form depends entirely on the careful rendering of the marginal shadows and the correct estimate of their proper tones. The position of the nipples and their relative position to the navel should be accurately determined, as these three points are of primary importance in the construction of the torso, or trunk, of the figure.

THE SHOULDER, ARM, AND HAND

23. The Humerus, Ulna, and Radius.—In the upper part of the arm there is a single large bone called the humerus. At its upper extremity it joins the shoulder, and at its lower

extremity it unites with two smaller bones, called the ulna and the radius, and forms the elbow. The ulna and the radius unite at the wrist with several smaller bones that extend to the joints of the fingers. In the construction of the forearm, as the lower portion of the arm is called, the radius is on the side of the arm where the thumb is, while the ulna is on the other side.

24. The Deltoid Muscle, and the Biceps and Triceps.—Over the shoulder joint where the humerus connects with the clavicle is stretched the deltoid muscle, which caps the shoulder like an epaulet, as shown at *c*, Fig. 8, and *b*, Fig. 5. The biceps muscle *e*, Fig. 8, which is prominent in the front of the upper arm, is forwards of the humerus, and the triceps muscle *d*, corresponding with it, is on the back of the arm. Thus, the upper arm is deeper than it is wide, owing to the fact that these two muscles lie on opposite sides of the bone, and its greatest dimension is seen when viewed from the side.

25. Pronation and Supination. — When the arm is in the act of **pronation,** that is, in the position shown in Fig. 9, the muscles of the forearm assume a widely different appearance from that seen when the arm is in the act of **supination,** as shown in Fig. 10. During pronation, the position of the bone of the forearm is distinctly seen by the shadow that runs to the point of the elbow. During supination, the bone is not seen, and the shadow shown is under the muscle. The contours on the upper and lower lines are changed completely, especially about the wrist. Familiarity with these forms is only reached through long practice in drawing from the figure and close observation. Therefore the details of the arm in both these attitudes should be carefully studied so that the difference in the contours of the muscles will be remembered. In pronation, the forearm has reached what is practically its extreme limit of range in one direction, and in supination it has reached the extreme limit in another direction. There are varieties of action between these two extremes that change the position of the muscles to such an extent that one must be thoroughly familiar with them in order to have the arm in good drawing, no matter in what position it may be.

26. The Arm.—In Fig. 11 is shown the male arm as seen

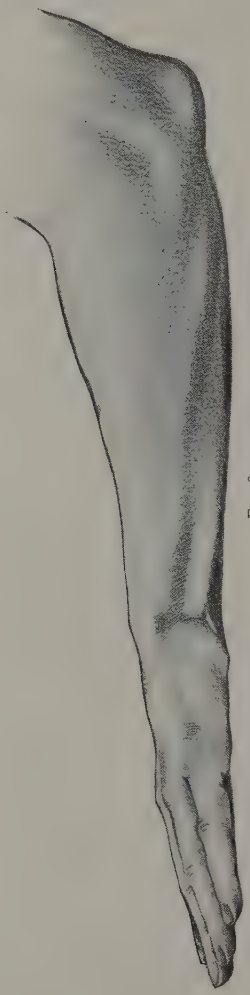

Fig. 9

Fig. 10

from a low point of view, in consequence of which it is considerably foreshortened. The shoulder cap, or deltoid muscle, here

becomes clearly defined, and the muscles of the forearm are shown rigid and full near the elbow, owing to the fist being clenched. The left-hand boundary line of the shadow on the inside of the arm indicates the intersections of the planes that give the contour in this position. In Fig. 12, the female arm is shown with a clenched fist. By being drawn up tight against the upper arm, the forearm is given a fullness near the elbow that is seen in no other position. The characteristic smoothness of the female arm is also shown. Even in this position the muscles are not knotty and hard as in the male arm, but the curves round off gracefully, one into the other, forming gentle undulations rather than sharp, emphatic curves. This is a characteristic that distinguishes all of the contours in the female figure from similar contours in the male figure.

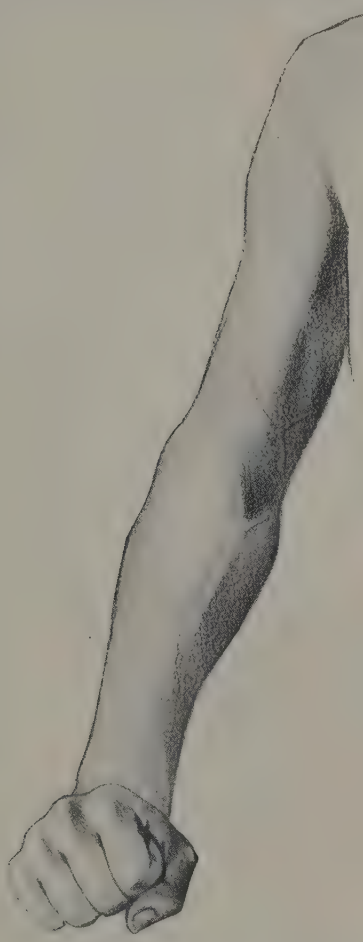

FIG. 11

27. In Fig. 13 is shown a muscular arm of the male figure, the development of which is clearly shown. The deltoid muscle of the

shoulder can be seen reaching like an epaulet from the top of the shoulder to the side of the arm and entering it in a blunt angle between the biceps muscle and the triceps. The triceps bulges slightly at the back of the arm, but its fullest part is nearer the shoulder than the nearest part of the biceps.

Fig. 12

Fig. 13

The muscles of the forearm are emphasized, as in Fig. 11, by the clenching of the fist, but if the hand were gradually opened the muscles on each side of the forearm would gradually flatten out and the fullness of the forearm spread somewhat toward the wrist.

28. In Fig. 14 is shown the male arm in a relaxed state, but the muscular development is sufficient to enable the power contained therein to be observed. Down the full length of the arm the shaded surface indicates the shape of the muscular forms beneath the skin and follows each concavity or convexity of surface on the side away from the light. The position of the elbow becomes marked by a sharp angle in the shadow, while on the back of the hand each knuckle and joint is expressed by a modelling of small planes of light and shade. The details of this illustration should be studied carefully, when it will be noticed that the prominent bone on the outside of the wrist and each of the joints of

FIG. 14

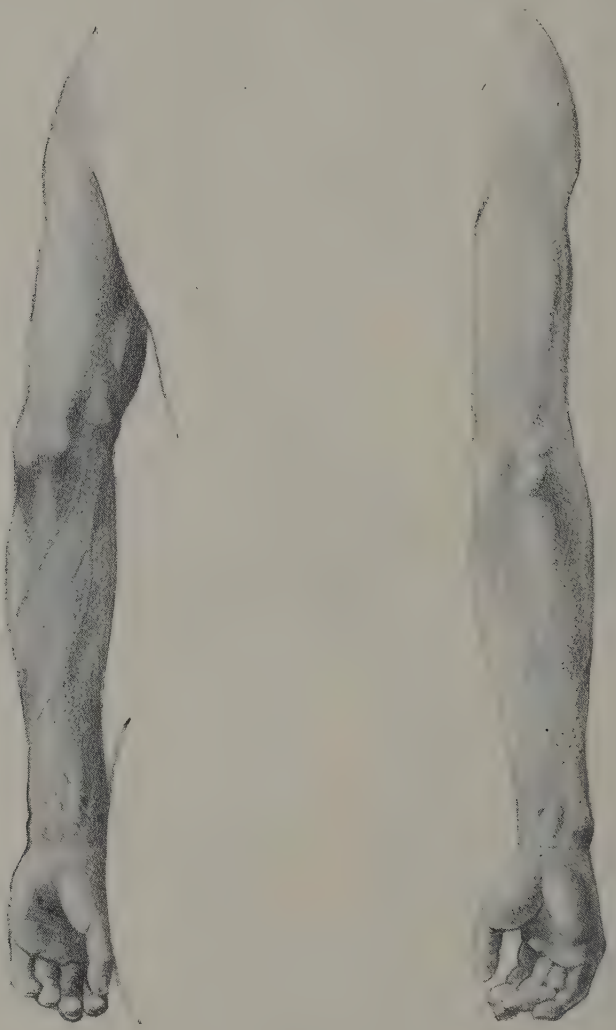

Fig. 15

the fingers are expressed by a little plane of light in just the right place.

29. In Fig. 15 is shown the construction of the arms and position of the planes of light and shade, when these members are seen from behind. The muscular development is slight and the position one of complete inaction and listlessness. The feeling of inaction is expressed by the flatness of the muscles and the evenness of the curves from one plane to another. Note the creases and folds in the skin that give character to the elbows and also to the expression of the ligaments in the wrist as they run from the muscles of the forearms to the fingers. Though none of the muscles is contracted, the shadows on the inside of the left arm show all the gradations of bone structure and muscle, and in many cases will even indicate the form, branching, and general distribution of the veins. In the right arm note particularly the thin appearance of the upper part; this is due to the fact that the biceps and triceps are set one before the other with the bone between them, so that the smallest dimension of this portion of the arm is shown. But the position of the forearm is such that the bones and accompanying muscles are seen from their widest standpoint. The relative widths and positions of the various proportions of the arms as they are turned in different positions should be studied carefully.

30. In Fig. 16 is shown a profile view of the female right arm. The upper arm appears rather short for the forearm, owing to the fact that when making this drawing the model was placed far above the eye. This foreshortening gives the effect of elevation to the figure. The left arm resting near the small of the back shows the smooth, graceful curves of the outside line of the female arm in this position, contrasted with the sturdy and abruptly changing planes of the male arm. In both the left and right arms, the unbroken smoothness of line characteristic of the female figure is shown clearly.

31. In Fig. 17, the thin, undeveloped arms of a young girl are shown. Here the chief interest centres in the foreshortening of the forearms and of the hands. In the model's right

Fig. 16

arm the wrist is entirely hidden, and unless the arm and elbow, as seen to the left and below it, are properly rendered, the union between the hand and the arm will not be indicated. This should be very carefully studied. In the model's left arm nothing is hidden, but the foreshortening must be carefully studied because the drawing of the arm in this position must

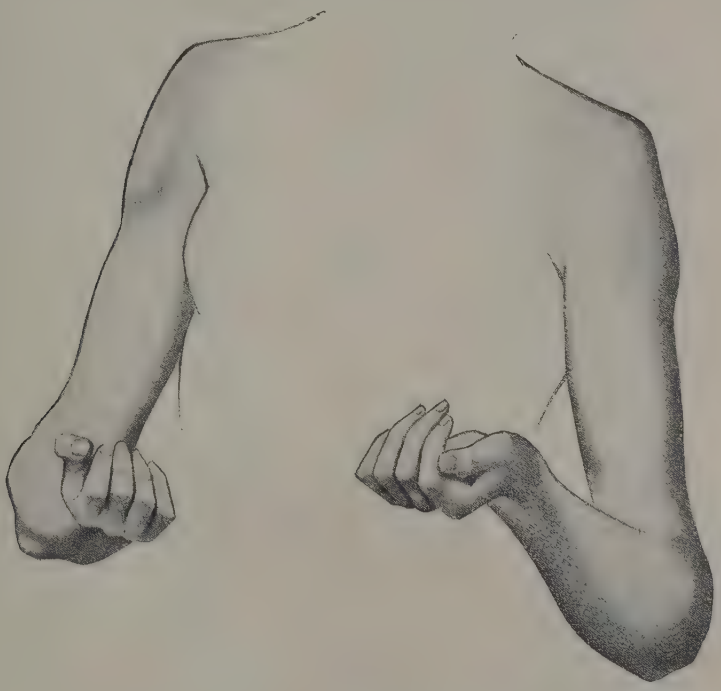

Fig. 17

be very accurate to obtain the desired effect. In this position the hands appear larger than they would ordinarily, as they are from 8 to 12 inches nearer the eye than the elbow. No set rule can be given for this foreshortening, but attention must be given to the proportions of all the parts in order that the foreshortening may be expressive of existing conditions.

32. The Hand.—The appearance of the hand is so influenced by perspective in all positions that actual measurements of its proportions are of little value. The forefinger and the third finger are usually of about the same length, and the distance from the knuckles of the forefinger to the joint of the wrist is approximately the same as the distance from the knuckles to the tip of the finger. The middle finger is longer than those next to it, and the little finger is the shortest of the four. The characteristics of the hand naturally vary with the individual. In the clenched fist the forms are very similar to those of a plain block hand, and in drawing details of the hand the same rules apply as in drawing the head or other parts of the figure. The mind and eye seize on prominent points for starting and finishing lines. These points vary with the position of the hand, but, generally speaking, the positions of the wrist, knuckles, and first and second joints of the fingers and thumb are to be determined first and the construction built round them; close drawing of the contours may then follow. The shadows should be carefully modelled so that their margins will be well defined, as the solidity of appearance is dependent entirely on the accuracy with which these shadows are handled.

THE THIGH

33. Position of the Principal Muscles.—In studying the thigh, it is well to know where certain muscles are placed, although this member is usually so covered with fat that it is difficult to find lines of separation between the various sets of muscles. When the thigh is made rigid by contracting its muscles, it will be seen that on the outside of the upper part of the thigh there is a large muscular prominence which forms a ridge that extends obliquely across the leg, from *a* to *b*, Fig. 18 (*a*), so that when it reaches a point above the knee it is on the inside of the leg. This ridge is made up of several large muscles, but their origin is difficult to trace on the figure, and consequently in rendering the thigh the eye must carefully search for shadows and their outlines in order that the positions and outlines of the muscles may be intelligently expressed.

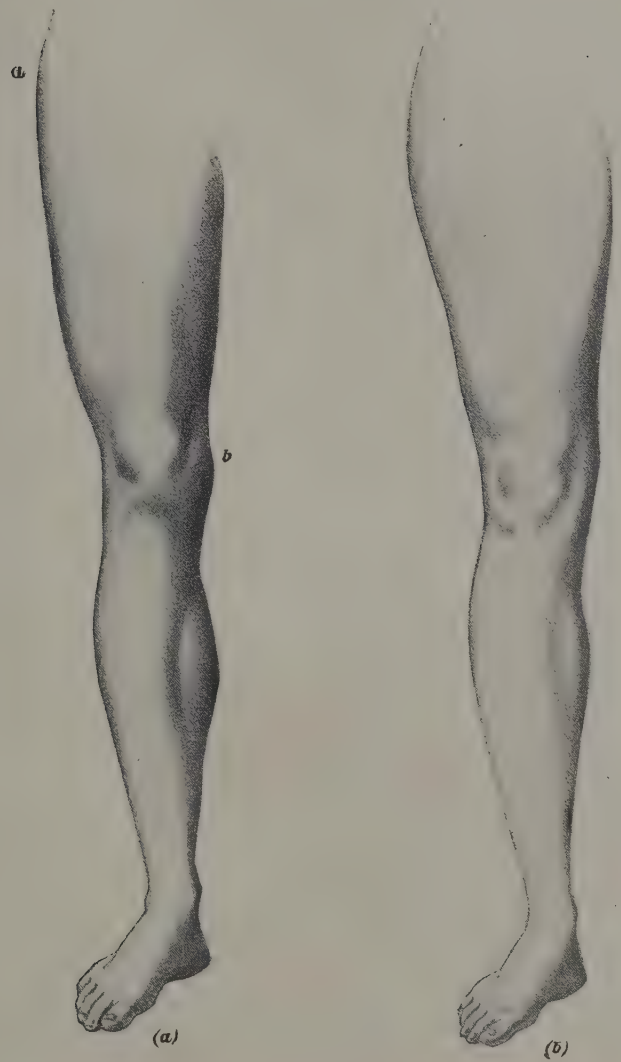

Fig. 18

34. The Biceps of the Leg.—The large muscle on the back of the thigh is known as the biceps of the leg, and has a use similar to that of the biceps of the arm; that is, to draw the lower portion of the leg upwards and toward it. Its prominence is plainly seen when the leg is viewed from the side, and gives the thigh, similar to the arm, a greater depth than thickness. The upper bone of the leg is called the femur; it unites with two smaller bones in the lower portion of the leg, called the tibia and the fibula. The thigh of a female is much larger in proportion to the calf than that of the male.

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THE LOWER LEG

35. It is seen from Fig. 5 that if the length of a standard male figure is divided into eight equal parts, the length of the legs is equal to four parts and that of the torso to three parts. The three principal muscles of the lower leg are the two large ones that form the calf, and a smaller one in front of the shin bone. Viewed directly from the front, the prominence of the calf is very marked. Its most prominent part on the outside of the leg is somewhat higher than its most prominent part on the inside of the leg, as may be seen in Fig. 18. In rising on the ball of the foot these muscles are brought sharply into prominence, and when seen from the back of the leg their form is very clearly defined. The shin muscle is brought into prominence by placing the heel firmly on the floor and drawing the foot upwards as far as possible. In profile, or side view, the shin muscle curves slightly forwards from the bone, and the greatest width of the calf is somewhat higher than a point midway between the kneepan and the sole of the foot, as shown in Figs. 19, 20, and 22. The position of the foot governs the appearance of the muscles of the leg in identically the same manner as the position of the hand governs the muscles of the arm. With every turn of the foot the points of muscular prominence vary.

36. The muscles on the inside of the leg are seldom so well marked in women as in men, the lines being much straighter on the inside, as a rule, and more curved on the outside. The

shaping of the muscles themselves, however, is practically the same, and the difference of appearance between the male and female is due almost entirely to the filling in of fat. Owing to habitual exercise, due largely to the difference of amusements among male and female children, the male muscles become strongly developed and less fat fills in between them. In the adult's leg, the male is characterized by a development that clearly shows the position of each muscle, whereas in the female, the curves of the leg are continuous and the delineation of the muscles are difficult to trace. There is a common tendency in the male figures toward a separation of the knees, giving a bow-legged appearance, while in the female figure the tendency is toward a knock-kneed appearance. This latter is intensified by the fact that the hips of the female figure are very broad and the lines from the hips to the knees taper very rapidly. Thus, this knock-kneed appearance exists even where, as a matter of fact, the limbs are perfectly straight.

37. Fig. 18 shows the comparative proportions of the male and female thigh and leg when viewed from nearly the same standpoint. Assuming the calves to measure practically the same in circumference, it can readily be seen from view (*b*) that the female thigh and knee are rounder and larger than the male and that the lines causing this appearance are on the outside of the leg. On the outside line of the lower leg, however, the contours are nearly the same; but on the inside line the most prominent point of the calf is higher and the prominence itself is considerably greater in the male figure than in the female. This difference of appearance is due largely to fat filling the space below the knee in the female figure, the muscular development of the male being more defined than that of the female.

In the comparison of these two limbs, the characteristic difference between the male and the female figure can be seen, the former being sharply contoured and muscularly expressive, the latter being soft and undulating in its form. When these two limbs are studied line for line, they will be found to possess at nearly the same points exactly the same curves and in the same directions, but the gradations from one curve to the other

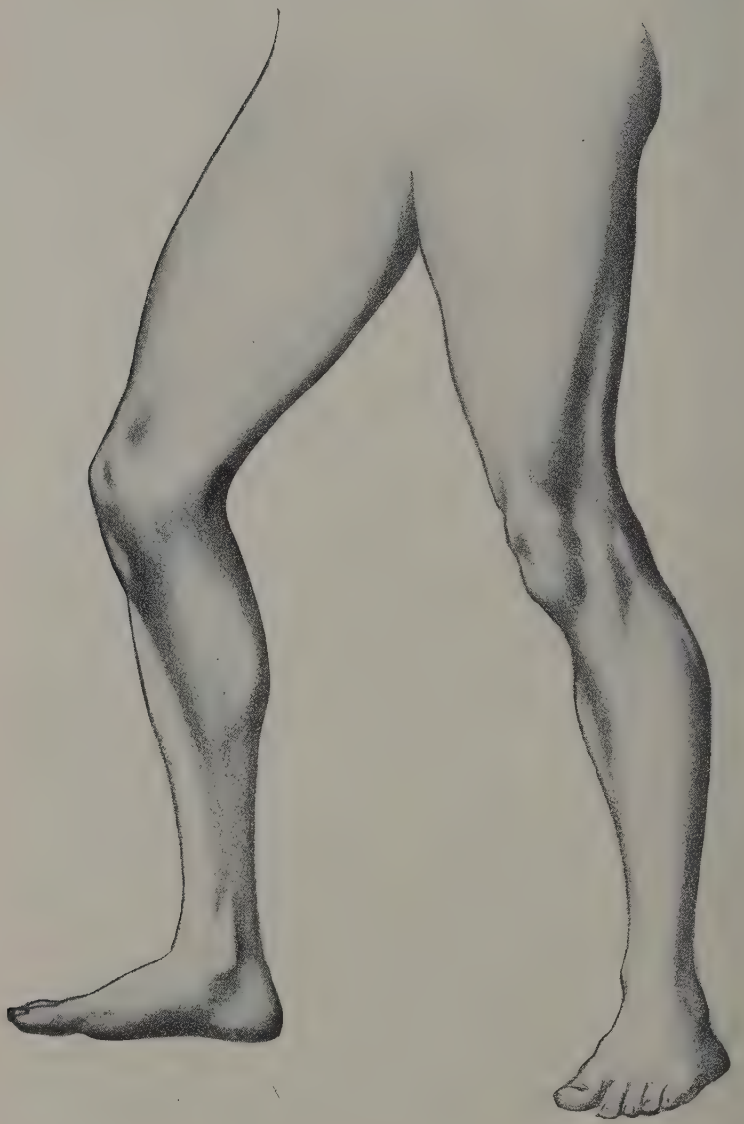


Fig. 19

are much more delicate in the female than in the male limb. Here, too, can be observed the cause of the appearance of knock-kneedness so prevalent in the female figure, the outside line of the leg exhibiting a greater indentation at the knee in the female than in the male figure. If a straightedge, however, is laid along the inside of each of these legs from the ankle bone to the top of the thigh, it will be found, as a matter of fact, that neither is in the slightest degree knock-kneed, but that the female limb tends to curve a trifle in the reverse direction.

38. Fig. 19 is a drawing of the male limbs with the weight of the body thrown forwards, thus bringing into prominence the muscle of the front of the right thigh and a fullness of the shin muscle directly below the right knee. The left leg exerts a backward pressure in this action principally on the toes and ball of the foot, and the clean definition of the thigh muscles just above the knee shows where the greatest strain comes. The muscle on the inside of the left calf also suggests pressure, and the expression of action in this figure is due entirely to the modelling about the knees and along the sides of the limbs that shows the tensity of this muscle. In the left leg, the curve of the shin bone from the knee down is strongly indicated by the shadow on the inside of the muscle at this place. The right foot is in full profile here, while the left foot is foreshortened in front view, and forms an excellent study of the positions and forms of the projecting parts on the ankle, both outside and inside.

39. Fig. 20 is a study of modelling to indicate the muscular forms in the male limbs when viewed from the side and posed somewhat as in Fig. 19, except that the relative positions of the limbs are reversed. The definition of the knee joint and knee-cap is very clearly marked here and the ankle bone stands out with great prominence, showing the point of hinge or turning at this member. The depression above the kneecap in the left leg appears here, giving fullness to the muscle above it in the same manner as in Fig. 19, but the point of view in Fig. 20, being farther to the right, the prominence on the inside of the calf has disappeared.

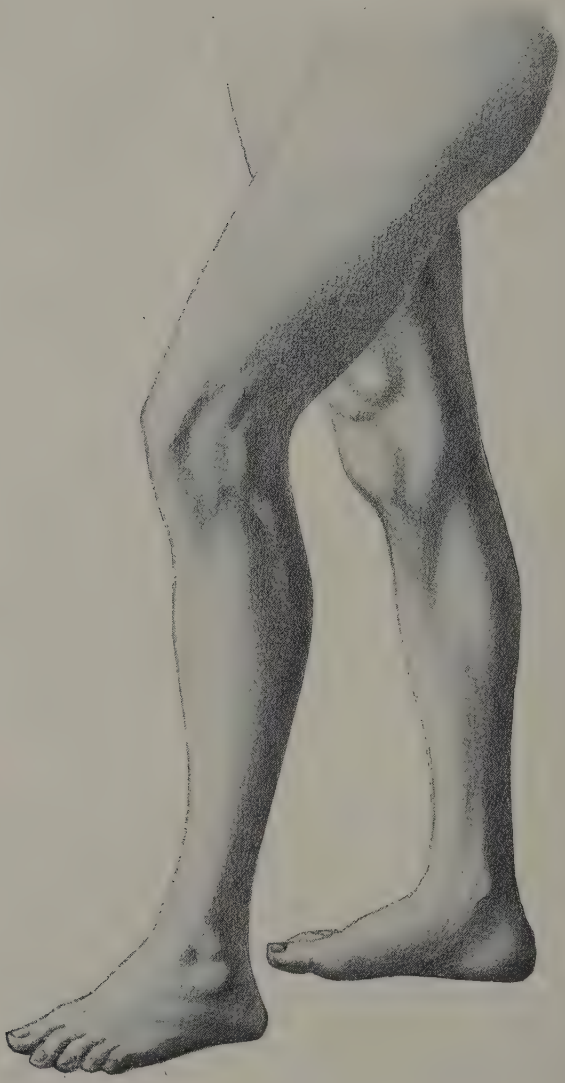


Fig. 20

In studying from the model, advantage should at all times be taken of opportunities to walk round it, and the change of contour noticed at each step. When stepping to the right or left of a certain point of view, certain muscles become foreshortened and others come into prominence, and it is only by the careful study of these that correct delineation can be given to the subtle character of the human figure. It is only by the repeated drawing from the figure in these positions that the details can be impressed on the mind sufficiently to permit the correct delineation of forms in illustrative work.

40. Fig. 21 is a view of the prominent points on the inside and outside of the left leg when seen from behind. In the outside of the thigh there is very slight convexity, while in the line of the inside there is a slight concavity about midway to the knee. The point of prominence in the outside of the calf is higher than the point of prominence on the inside of the calf; the position of these points of prominence is an important detail that should be studied from the living model, as the position of the feet affects to a great extent the general contour of the leg. For instance, in Fig. 21 the foot of the left leg rests at a given angle, thus causing the contours of the leg to assume a certain definite form, but the foot of the right leg is turned outwards and the contours of this leg are considerably changed. Not only is it important to establish these contours correctly in order to satisfy the eye as to the accuracy of the drawing, but the shadows indicating the various planes must be well placed, or the whole composition will be incongruous and unsatisfactory.

41. In Fig. 22, the smooth, constantly curving outline is strongly indicative of the female figure. The flesh lies so smoothly over the muscles that their characteristic prominences are almost entirely hidden. A comparison of these rounded, undulating forms with the knotty, muscular development of Figs. 19 and 20 again illustrates the distinguishing characteristics of the male and female figure. Here, as in Fig. 18, the thigh is shown round and full, and the construction here and in the knees is almost entirely obscured by the presence of fat.

Fig. 21

Fig. 19 showed a profile of the right foot as seen from the inside, while Fig. 22 shows a profile of the left foot as seen from the inside. The one being male and the other female, however, there are slight differences in contour, but the rise of the ankle from the instep and heel can be profitably studied from both points of view.

42. In Fig. 22, the comparative size of the thigh and calf of the female figure are well shown. Owing to the anatomical character and great width of the female hips, a large thigh is a necessity in order to give grace to the leg; otherwise, the lines from the hips to the knees would be concave, giving an appearance of awkwardness and weakness. Here can also be observed another characteristic that offsets this tendency to weakness in appearance; that is, the fullness of the calf on the outside and the tendency of the same to a straight line on the inside. The right foot here is in full front view, and the lower right leg is shown foreshortened, as it is seen from a point considerably above the knee. The foreshortened left foot in Fig. 19 was seen from a point very little above its level. In the right foot shown in Fig. 22, the two prominent points of the ankle bone should be studied carefully. Whenever opportunity arises this should be studied from the living model, inasmuch as the points of prominence on the inside and outside vary constantly with changes of position.

THE FOOT

43. In drawing the foot in profile, estimate its length by comparison with some fixed scale of measurement, such as the head, or by the proportion it bears to the length of the leg from the knee to the sole of the foot. The contour of the instep, the position of the ankle bone, and the shape of the heel are next in importance. In its main lines the form of the foot will be clearly seen from Fig. 23. The surface, being made up of a variety of planes and gradation of tones, makes the modelling rather difficult. In the full front view, the size and position of the toes and the relative position of the outside and

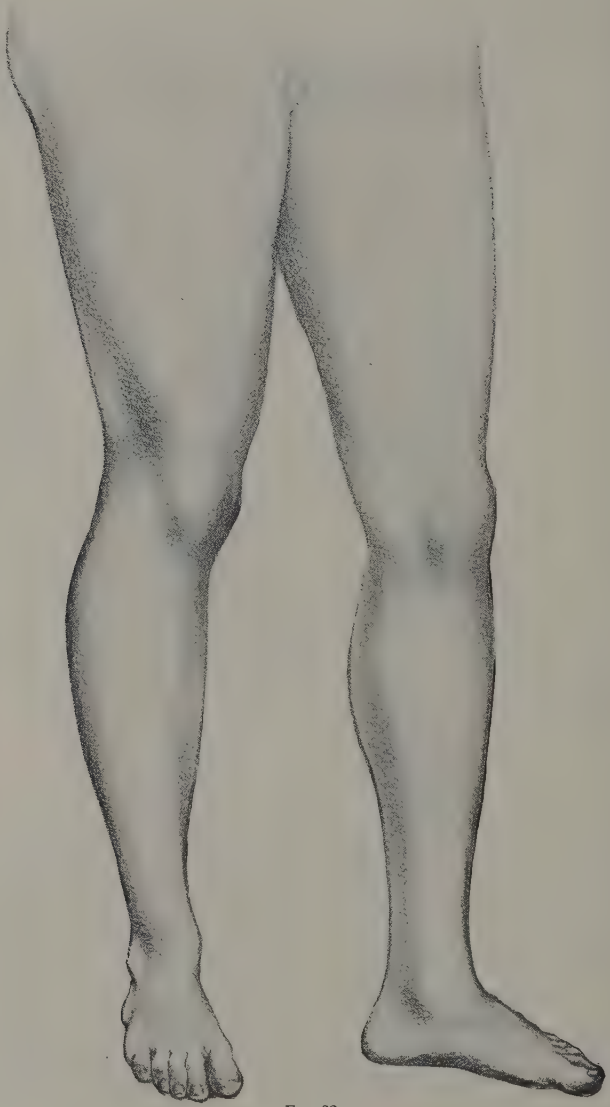


Fig. 22

inside prominence of the ankle bone are very important, and must be studied very closely.

When the relative positions of the inside and outside ankles are studied, it will be noticed that they are not at the same height above the base line of the foot, as is often seen in faulty drawings, but that the inside ankle is higher. This difference in height is clearly seen from the right foot in Fig. 22, and also from the left feet in Figs. 19 and 21. On comparing the two ankles of the left and right foot in Fig. 20, it will also be noticed that the near ankle is lower.

Fig. 23

In Fig. 23, it will be seen that the ankle and heel are indicated by a somewhat complicated combination of light and dark surfaces that require careful study. Great care has been used to indicate the slanting surface from the top of the instep to the point of the big toe. The toes themselves are brought out in strong relief by a combination of high lights in juxtaposition to surfaces in strong shadows. The positions of the toes with reference to the block on which the foot rests are indicated by a series of small carefully drawn curves.

Other points that require careful attention are the curvature of the instep on the inside of the foot, Fig. 20, and the gentle curve on the outside of the foot, which contribute so much to the imparting of grace to the drawing of a foot. In representing a foot in a front view the directions of the toes should be noticed. The big toe points in the general direction of the foot, while the smaller toes point outward, as seen from Figs. 19 and 22.

There are many other smaller muscles throughout the body that are of importance in artistic anatomy, but the ones given have the most direct influence on the shapes of different parts of the body in various positions, and should be studied carefully whenever opportunity affords, in order that their true value may be appreciated.

THE FEATURES OF THE FACE

INTRODUCTION

44. The expression of the eye is almost entirely dependent on the shape of the eyebrow, the lids, and the bone structure in which it is set. All the varied expressions of love, pity, fear and grief, indignation and joy are due to the muscles round the eye and not to any expression of the eyeball itself. The nose shows considerable character in its formation, but is only slightly mobile or changeable, being restricted to the variation in the dilation or size of the nostrils and a few other trifling muscular movements, such as the raising of the end in an expression of deep appreciation or disgust. The mouth, with the eye, possesses the greatest range of mobility and contributes most to the variation of expression in the face. The ear and chin are the least mobile of all the features, and depend for their character entirely on their general formation. In constructing the head, the ears are a great help, as an imaginary line through them may be supposed to form an axis on which the head may be said to turn ; their position on each end of this axis establishes the angle at which the head is seen.

THE EYE

45. The correct drawing of the human eye is one of the most difficult problems. The convex shape of the eyeball enveloped by the lids gives opportunity for a great variety in the positions of both. In general structure, the eyeball protrudes from a socket, or orbit, as it is called, and is enveloped above and below by the eyelids, as shown in Fig. 24. The front plane of this orbit slopes inwards as it descends to the cheek bone, as indicated by the line *a b*, Fig. 25, and makes an angle with the general plane of the forehead as the latter recedes from *a* to *d* and also with the plane of the upper part of the cheek, as shown at *b c*. The relative position of the various parts of the eye, whether the latter is opened or closed, tends to preserve the direction of the plane *a b*, and the eyeball never protrudes sufficiently from its socket to break the continuity of this plane. The upper lid extends over and partially covers the upper portion of the iris, while the general plane of the iris slopes backwards with the plane of the orbit. The under lid is thinner than the upper and forms the lower part of the plane *a b*, where it intersects with the cheek plane.

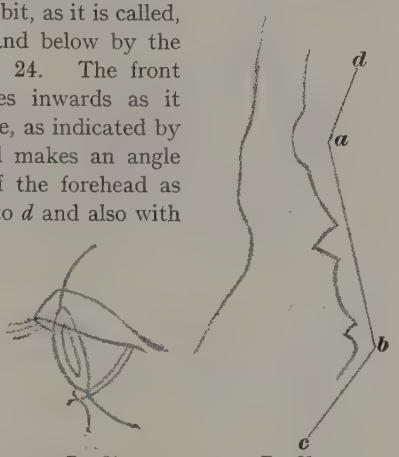


Fig. 24 Fig. 25

46. The eyebrows start either side of the nose just under the frontal bone and extend outwards and slightly upwards, tapering gradually toward the temple, where the growth ceases on the outside of the orbit, as shown in Fig. 26. The convexity of the eyeball determines the curvature of the eyelids, but this curvature changes with every position of the head, owing to the foreshortening of the lids. In three-quarter view, the outer edge of the upper lid assumes a position that hides the thickness

of the lid, as shown at *a*, Fig. 27, while in looking downwards the upper lid straightens out and the lower lid becomes more convex, owing to the fact that the eyeball is rolled into the lower lid, as shown in Fig. 26. As the eye is turned downwards, the outer corner descends slightly also, tending to straighten out the lower lid. When the eye is rolled upwards, the convexity of the eyeball is emphatically marked by the upper lid,

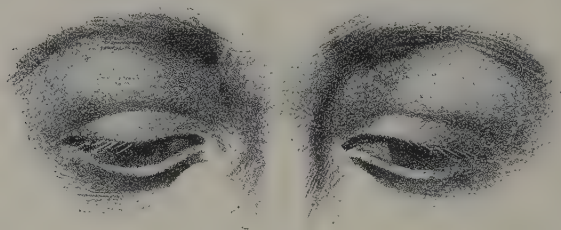


Fig. 26

as shown in Fig. 28; its breadth is diminished, but its thickness is visible all the way across, while the lower lid flattens out and forms a compound curve rising from the inner corner and then descending until past the pupil, when it rises abruptly to the outer corner. With most persons, the upper lid is more

Fig. 27

Fig. 28

convex on the inside than on the outside, while the lower lid is more convex on the outside. From the outside of the corner of the eye the upper lid curves slightly toward the top of the iris, and then descends in a more or less abrupt curve to the tear gland by the nose, while the lower curve starts straight from the tear gland, descends slowly, and returns in a rather more abrupt curve against the outer corner of the upper lid, so that

lines drawn through the points of start and finish in the eye will intersect about as shown in Fig. 29. The eye very rarely

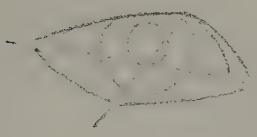


Fig. 29

Fig. 30

composes itself into two even arcs from corner to corner, as shown in Fig. 30.

THE NOSE

47. Viewed directly in profile, the nose starts beneath the eyebrows and proceeds at an angle with the general plane of the face until the tip is reached. The character expressed by

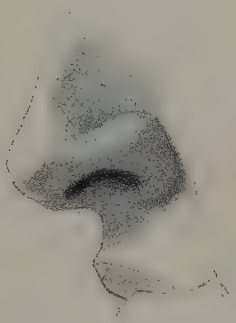


Fig. 31

Fig. 32

it is mainly influenced by the bridge, while the terms Roman, straight, aquiline, and retroussé (turned up) are based on the degrees of convexity or concavity of the line from the brows to the tip. The upper lip joins the cartilaginous septum, or partition, between the nostrils at a point about midway between the extreme tip of the nose and the crease where the wing of the nostril joins the cheek, as shown in Fig. 31. When

illuminated by a strong light, the margins of the shadows definitely outline and fix the planes that make up this feature.

48. In a full-face view, Fig. 32, the nose has its origin between and somewhat beneath the brows. At its beginning it is narrow and increases in width at the bridge ; it decreases where the cartilage is reached at the end of the nasal bone, but again increases, attaining its greatest width at the tip. The nose is wedge-shaped in this view, with the edge of the wedge to the front ; the sides slope gradually from the bridge to the cheeks until the nostrils are reached. The base of this wedge projects outwards from the general plane of the face, as the nose is much broader at the base than at its origin between the brows. If this point is not well understood, drawings of the nose are likely to look as if the nose were pressed

FIG. 33

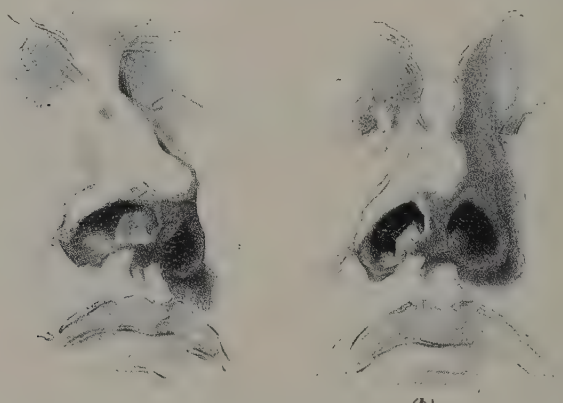


FIG. 34

into the face between the cheeks. A block form of the nose is shown in Fig. 33. A sharp crease marks the formation of the wing of the nostril at the base and lessens in prominence as it extends into the cheek. The greatest width of the nose is at the base across the nostrils.

49. When the nose is seen on a level with the eye of the observer, the cartilaginous septum between the nostrils extends slightly lower than any other part, as shown in Figs. 31 and 32. When viewed from below, however, the wings appear to be the lowest part, as in Fig. 34 (*b*) ; but viewed from above, the nostrils are completely hidden, and the lower part of the tip overhangs the upper lip, as shown in Fig. 35. When the head is thrown well back, as in Fig. 34 (*a*) and (*b*), the formation of the nostrils and the intervening cartilaginous septum can be easily studied. The unconventionality of these forms makes definition difficult, and much practice is therefore required before they can be drawn correctly. The convex surface of the wings and the end of the nose should be studied in profile, full-front, and foreshortened views. The shadows on these parts better illustrate their true form than any verbal description can possibly do. When seen from below, the bridge from the brows to the end will lose greatly in length by foreshortening, and must therefore be carefully studied in order to avoid an exaggerated appearance.

Fig. 35

THE MOUTH

50. The mouth, like the eye, is one of the most difficult parts of the face to render correctly, inasmuch as its form is so subtle and so greatly influenced by the curvatures of its surfaces that constant practice is the only means by which proficiency in drawing it can be attained. Viewed in profile, as shown in Fig. 36, the general formation of the lips can be studied. The points found by the intersections of the nose and chin with the plane tangent to the lips should be noted. In the full-front view, Fig. 37, the upper and lower lips are seen to be concave in their outlines from the middle to the corner. The upper lip, as shown in Fig. 36, when considered

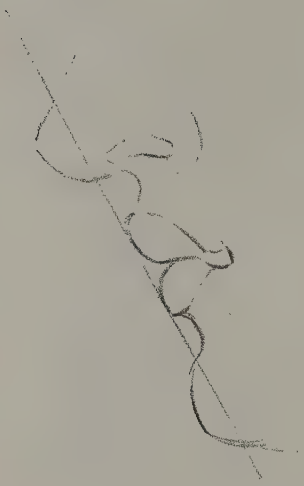


Fig. 36

Fig. 37

Fig. 38

Fig. 39

as a whole, is much more convex than the lower one, and the curves pass almost imperceptibly into the adjacent curves. In the full-face view, Fig. 38, the mass about the mouth is very convex owing to the presence of the teeth. The corners therefore are farther back than the middle and the concave sides become foreshortened. In the average mouth the upper lip overhangs the lower lip slightly, and in a direct profile view, Fig. 39, the corners will be found somewhat lower than the drooping middle portion of the upper lip. The mucus, or red, portion of the upper lip may be divided into two planes *a* and *b*, Fig. 40, while the lower lip possesses three planes, the middle one *c* extending each side of the centre of the upper lip and the two side ones *d*, *d* extending into the corners of the mouth. The curvature and fullness of the lips is a matter of individual character, varying from a distinct bow shape to lips that are so thin and straight as to be scarcely more than a straight line across the face.

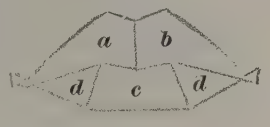


FIG. 40

51. The concavity beneath the lower lip, as seen in Fig. 39, is largely influenced by the fullness of the lip itself and the pressure brought to bear on it by the upper lip. The depression that divides the upper lip beneath the nose, as shown in the front view, Fig. 38, widens as it descends toward the mouth and marks the middle of the upper lip. The little concave depression in the middle of the upper curve of the upper lip seems to be duplicated in the lower curve of the upper lip, both curves forming the boundary to the thickness of the lip at this point. From the middle, the upper lines of the upper lip curve downwards toward the corners, while the lower lines of the upper lip follow approximately the same direction, and the two meet in the depression at the corner. In direct front view, the degrees of convexity and concavity in the form of the lips are expressed by the intensity and shape of the shadow.

52. In the various foreshortened positions in which the mouth is frequently seen, the lips assume many changes in appearance. It is plain that when observed from a point of

view below the mouth, the upper lip will appear at its full thickness, as shown in Fig. 41, and the lower lip will appear thinner than when seen level with the eye of the observer. When seen from above, as shown in Fig. 42, the lower lip will exhibit its

FIG. 41

FIG. 42

full thickness, and the upper lip will appear thinner than when seen on a level with the eye.

53. In the three-quarter view, Fig. 43, the nearer side of the mouth from the middle to the corner is seen in its full dimension, losing nothing by foreshortening; the other side,

FIG. 43

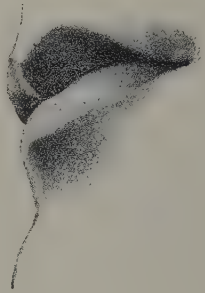


FIG. 44

however, appears much shorter, and in some cases the space between the middle and the farther corner will be lost entirely. A three-quarter view of the mouth from below, Fig. 44, produces a change in dimensions from two causes, as the point of view is not alone to one side, but is also below the mouth. The

curves seen from this position, as well as those appearing in a three-quarter view from above, should be carefully studied.

FIG. 45

FIG. 46

54. The mouth and eyes combine to give various expressions to the face. When the lips are parted slightly, as in Fig. 45, the teeth show within, and a half-smiling expression is given this feature by slightly raising the corner. In front and three-quarter views the lips lengthen and flatten out in the act of smiling, as shown in Fig. 46. In Fig. 47 is shown the mouth illustrated in the previous figure. Note the foreshortened profile line through the centre of the lips and chin. This line is identical with the profile shown in Fig. 36 except that the lips are parted.

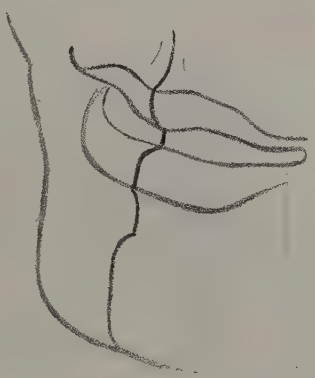


FIG. 47

THE EAR

55. Viewed in profile, with the eye of the observer on a level with the ear of the model, the top of the ear will be about on a level with the eyebrow and the bottom of the ear will be nearly

on the same line as the base of the nose, although this detail varies in different individuals. The ear occupies a position somewhat to the rear of the centre of the head, and in the classic figure the top of the ear is tangent to a line supposed to be drawn

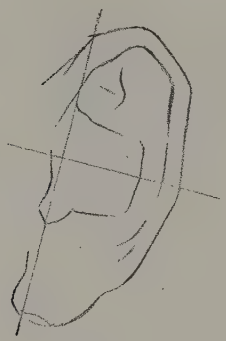


Fig. 48

Fig. 49

Fig. 50

Fig. 51

midway between the top of the head and the bottom of the jaw. The general direction of the ear is slightly at an angle to the vertical, as shown in Fig. 48, a line drawn through its central opening pointing toward the junction of the chin and the throat. The form of the ear is decidedly irregular, and must be studied

carefully to be well understood. In its numerous concavities and convexities various shadows are cast, in the correct determination of which lies the secret of rendering it properly. These shadows indicate every winding recess of the bowl and every prominence and hollow in the brim. In the front, or three-quarter, view, Fig. 49, the lobe of the ear is close to the head, but the upper part is much less so, as is readily seen when the ear is viewed from behind, as in Fig. 50. In Fig. 51, the ear is shown in full view as it appears when the head is in profile. The distinguishing characteristics of the ear and the variation in form found in different persons met with in everyday life should be carefully noted.

The ear is very intricate in its formation, and in views showing a foreshortening of the head the proper placing of this feature is of the utmost importance. As said before, a line through the head from one ear to the other forms an axis, so that the placing of the ear is a sort of key to the position of the head.

THE CHIN

56. The under side of the chin when in profile is about one-third the length of the face. It may also be said to be equal in length to that third part of the face that is situated below the nose. The back part of the head at the point where it joins the neck is about on a level with a horizontal line drawn across the head at the base of the nose. Thus, it will be seen that the front of the head bears a proportion of three parts to two when compared with the length of the back of the head, and that this extra third portion includes the mouth and chin. Where the head is thrown well back, the back portion of the head is lowered and the chin raised, and great care must be exercised in order that their proper relative positions are preserved. When observed from below, the chin is more in the foreground than any other part of the face ; but when observed from above, the chin is more in the background than any other portion of the face. Observance of these effects is of the utmost importance in rendering these details.

DRAWING THE FULL-LENGTH FIGURE

LIMITATIONS TO MOVEMENT

57. In drawing the full-length figure it is of the utmost importance that the relative positions of the various parts should be such that they are within their possible range of motion. For instance, when viewed from the back the neck has a limited range of movement beyond which it cannot turn, and if a drawing represents a head in one position and the back and shoulders in such relation to it that it is unnatural, the whole drawing is bound to appear untrue to nature. Also, in a drawing of a leg where a view of the knee, the foot, and the ankle is given, it must be borne in mind that with various positions of the foot and ankle, certain corresponding positions of the knee must be represented, and anything beyond these throws the body out of its true position. When the hand is in pronation, the muscles of the forearm assume certain prominences, and care must be taken that these prominences are not shown when the hand is in supination or in any intermediate position.

Whatever portions of the body are turned by strong action, all have a limit to their change of position, and all the prominences of the muscles are each characteristic of certain positions. When these details are shown where, under the prevailing conditions, they cannot possibly be, the drawing is not alone not true to nature, but it tends also toward a line of work known as caricaturing, where grotesque forms are produced by the introduction of impossible forms and positions. Probably the most prominent defect of this character is seen in some cheap lines of illustration where the neck, because it is turned beyond its limit of movement, appears stiff and unnatural, a common characteristic of the work of the untrained artist.

58. It is a common error of beginners to endeavour to draw everything in outline before any attempt is made at construction or building up. The whole model should be viewed as a large simple mass, and all the details should be omitted until

the general plan is completed. Erasures should be avoided as much as possible, and until the general construction lines are correctly placed and drawn, no modelling should be attempted. The work in cast drawing of block forms of the hand and head should be borne in mind, and the simplicity of mass in these details should be fully applied to drawing from life. After the main directions and proportions are rendered, a careful study of the outlines can be made, substituting accurate lines of contour for the simple lines of construction. But it should be borne in mind that good work in modelling can never be accomplished unless the structural form is correct to start with. While it is bad practice to endeavour to draw figures out of the mind, it is good practice to draw carefully from life and then, without the aid of either the model or the original drawing, to redraw the figure from memory. This second drawing can be compared with the drawing from life to see where the memory has failed, thus impressing on the mind certain details that are not likely to be overlooked again.

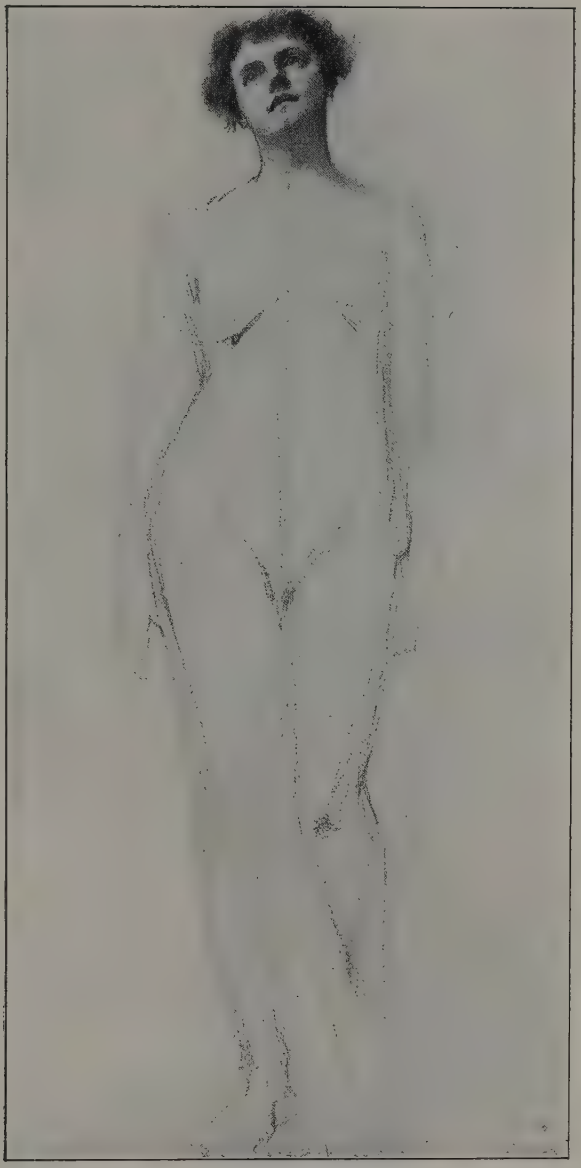
59. It is a good plan to walk slowly round the model and observe the difference in appearance that the various parts assume with the change of position. The eye will thus become accustomed to the appearance of the figure in its common attitudes and the relation that various forms bear to one another. When parts of the body are known to be correctly placed and to occupy the proper amount of space on the drawing paper, they should be drawn carefully in detail, as, for instance, the ankle and foot or the wrist and hand, and the memory test should then be applied to these details also. While the position and proportion of the torso, or trunk of the body, is of vast importance, most of the practical work in life drawing requires more minute familiarity with the details of the head, hands, and feet. The rest of the body is often covered with clothing, which adheres more or less closely to the form but is not directly influenced by muscular prominences and developments. The position of the arm, however, the folds of the draperies, etc., should always be closely studied, as in the draped figure these details take the place of the change of muscular forms that are

found on the nude figure whenever its position is changed. In most drawings the foot is clothed with a shoe or slipper that makes modelling of the individual toes unnecessary, but the position of the ankle and the change in curvature of the line that joins the lower leg to the foot are matters of greatest importance, greater even than the actual modelling of the foot itself.

EXAMPLE

60. In Fig. 52 is shown a reproduction from a typical drawing from life, showing the general blocking in of the main outlines. In this drawing only the general action and swing of the body are indicated, and no attempt has been made to give any definite character to the form or the line. The position is such as would indicate that the weight is strongly thrown on the right leg and foot, thus giving the right hip considerable prominence, while the lines of the left side are comparatively straight from the armpit to the inside of the knee. The median line down the centre of the body is scarcely discernible, but to either side of it are built the masses that constitute the two sides of the figure. These structural lines are very faint, and somewhat difficult to trace, yet they are sufficiently clear to express the action, and the method followed in drawing them is considered the correct one for the commencement of a drawing that is to be finished in detail. The width of the shoulders and the length and outlines of the arms are but faintly suggested, but these, together with the positions of the hands and hips, are sufficiently indicated to give their main positions and dimensions, without in any way carrying the work forwards to definite contours.

61. The only portion of the figure that is carried to any state of completion is the head ; and this is modelled in in a very simple manner. The secret of this modelling lies in the very close observance of the margins of the shadows, even though they are kept down to one tone. The drawing of the figure as a whole is broad and open, and no attempt has been made at completing the detail of it. Its purpose is to get the general



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Drawn by Melvin Nichols

FIG. 52

outlines of the figure on the paper so that details may be filled in afterwards in their proper places. Rough and almost careless as some of the lines may appear, each line has been studied from life both as to its direction and effect, the effort being to secure action with the fewest possible lines.

DRAWING PLATE, TITLE: MALE FIGURE

62. In the plate entitled Male Figure is shown a finished drawing in which the chief point of interest lies in the foreshortening of the various parts. While the drawing of this plate will give an idea of the method by which to obtain the results shown, it must be remembered that the mere copying of drawings is, after all, a poor method of becoming familiar with the characteristic features of the figure. It is therefore necessary that, as much as possible, drawings should be made from the live model, and that every opportunity to do so should be utilized.

To commence work on this plate, pin a sheet of paper on to the drawing-board, large enough to include the border lines enclosing the drawing of the figure. The distance between the top and bottom border lines should be 17 inches, and between the left- and right-hand border $8\frac{1}{2}$ inches.

63. The drawing of the figure is commenced by fixing the positions of important points of the figure on the drawing paper, such as the top of the head and shoulders, the waist, knees, and ankles. Then sketch in the sides of the shoulders, waist, etc., and indicate in a sketchy manner, similar to that shown in Fig. 52, the general outline of the figure. Every line of this sketch must be put in for some purpose and in its correct position, the first aim being to fix the action of the figure in the drawing. When this sketch outline has been made correctly, it may be used as a foundation on which to build up the more complete outline of the figure, then more detail may be added.

64. By carefully studying the drawing plate, it is evident that the eye of the artist who drew the original was about on a level with the ankle of the model. As the figure leans slightly

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forwards, parts of it, especially the left arm and shoulders, are considerably foreshortened. The left elbow becomes very prominent, while the forearm tapers rapidly to the wrist owing to the fact that it is more distant. The right arm is similarly drawn, the taper of the muscles of the elbow to the wrist being even more conspicuous here. Note the vigorous treatment of the outlines where a series of simple lines block out the general form. The high light under the left arm tends to throw the left arm into the foreground apparently and to increase the effect of foreshortening. The lines across the shoulders and hips are at such an angle that the height of the figure above the eye is easily realized. In rendering this figure, close attention should be given to the contrasting of high lights and shadows as well as to the blending of subtle variations, one into another. After rendering the drawing in as careful a manner as possible, spray it with fixatif, insert name, date, class letters, and number in their usual places, and send in the plate for criticism.

DRAWING PLATE, TITLE: FEMALE FIGURE

65. In the plate entitled Female Figure is shown another drawing of a female figure, finished in somewhat more detail than that shown in Fig. 52. Although delicate modelling is indicated in this drawing, no attempt has been made to produce a completely rendered composition. The pose has been selected to show the beautiful curve in the back, as well as the profile of the breast and the upper portion of the body. The general direction of the left leg gives the line of support, and the relative points of prominence in this member as seen from behind can be compared with the relative points of prominence studied in connection with the front view, Fig. 52. The outside of the thigh in the right leg is slightly convex, while the corresponding line on the inside of the thigh has a tendency to be concave. The positions of the feet govern the appearance and points of prominence of the leg. In the left leg the foot rests at an angle with the floor, but in the right leg the foot is turned in profile and is flat on the floor,

thus changing the contours accordingly. From the back of the neck to the hollow of the back is an even, graceful, convex curve. At the back it becomes concave and swells again to the thigh. The left arm, extending to the ring that is grasped by the hand, exhibits some of its muscles in prominence. Here the triceps swell out to join tangentially the curve from the back of the neck to the back of the body. The muscles of the forearm are necessarily prominent, owing to the weight that is thrown on the wrist. The fullness of the chest is shown above the left breast, and a nearly straight line extends from the under side of the right breast to the navel. The whole composition is one of ease and grace, and gives a good idea of the manner in which a drawing from the life should be completed for purposes of study.

66. In modelling, all the shadows in the upper part of this figure should first be indicated by lines, graded afterwards with the stump, and worked over again in lines with the crayon point to give transparency. The right hand appears over the top of the head, the entire arm being lost on the other side of the figure.

Great care must be exercised in drawing the lines of the neck of this figure so as to avoid a distorted or unnatural appearance. The figure is posed above the eye in such a manner that the under side of the chin and tip of the nose are barely visible. The head is turned so far away that the socket of the eye is scarcely visible. In rendering this figure the aim should be to indicate the head with a few masses of light and shadow, rather than by outlining in detail. The deepest shadows are under the left breast and in the hollow of the back, but they rapidly blend off into the middle tone.

This plate is an example of delicate modelling, and no attempt should therefore be made to carry the modelling any farther than indicated on the plate. Only outlines of masses are to be shown. After completing this drawing, it should be carefully sprayed with fixatif ; then insert name, date, class letters, and number in their usual places, and send in the plate for correction.

A SERIES

OF

QUESTIONS AND EXAMPLES

RELATING TO THE SUBJECTS

TREATED OF IN THIS VOLUME.

The following Examination Questions are divided into sections corresponding to the text, so that each section has a head-line which is the same as that of the section to which the questions refer.

No attempt should be made to answer the questions or to solve the examples until the corresponding part of the text has been carefully studied.

GEOMETRICAL DRAWING

NOTE.—It is very important that students carefully study and fully understand the preliminary directions for the manipulation and use of the instruments and materials given on pages 1 to 25 before attempting to draw the plates. A clear understanding of these directions is absolutely necessary in order to make satisfactory progress. Please write the answers to the following questions on thin, tough, writing paper, and enclose them with your drawing of Plate I when sending the same to us.

EXAMINATION QUESTIONS

(1) How should the drawing board be placed?

(2) (*a*) What size of paper is required for the drawing plates? (*b*) What qualifications must the paper have in order to be suitable? (*c*) What should be the size of the drawing inside the border lines?

(3) (*a*) What kind of pencil should be used for the pencil work? (*b*) What kind of point should it have? (*c*) How should the lead for the compasses be sharpened?

(4) By means of what instrument are straight horizontal lines drawn?

(5) Against which edge of the drawing board is the head of the **T** square placed?

(6) By what means and how are vertical lines drawn?

(7) By what means are parallel lines drawn that are neither vertical nor horizontal?

(8) (*a*) With what instrument are circles and arcs drawn? (*b*) For what is the lengthening-bar attachment used? (*c*) How is the joint at the top of the compasses adjusted? (*d*) Why is each leg of the compasses jointed?

(9) (*a*) How are the compasses held when drawing circles? (*b*) When may both hands be employed in using the compasses?

(*c*) How can the needle point of the compasses be prevented from digging large holes in the paper ?

(10) (*a*) With what instruments are small circles drawn ? (*b*) How must their points be adjusted to draw very small circles ?

(11) (*a*) What instrument is used for dividing straight lines and circles into equal parts ? (*b*) Describe how to space a line or circle into a number of equal parts.

(12) (*a*) By what means are curves other than arcs of circles drawn ? (*b*) When a series of points through which the curve line is to pass is determined, how is the line drawn ? (*c*) How is the tendency avoided of making the lines curve out too much between points ?

(13) (*a*) What instrument is used for drawing all ink lines other than arcs or circles ? (*b*) How should it be held ? (*c*) If it is not held properly, what kind of lines result ?

(14) What instrument is used for laying off measurements on the drawing ?

(15) What instrument is used for measuring and laying off angles ?

(16) (*a*) What kind of ink is permissible on the drawing plates ? (*b*) For what purpose is the quill attached to the cork of the bottle ? (*c*) What is liable to happen if too much ink is put in the pen ? (*d*) Why is liquid ink considered better and more suitable for this work than stick ink ? (*e*) What is the remedy when ink dries between the blades of the pen and refuses to flow ?

(17) (*a*) Is the lettering on the plates printed or written ? (*b*) Give the size of the letters. (*c*) At what angle should the letters slant ? (*d*) What writing pen is considered the best for inking the letters ?

(18) (*a*) On which plate are the block letters first used ? (*b*) Are the block letters made freehand ? (*c*) What is their height ? (*d*) What is the width of the letters *M* and *W* ?

(19) How many plates are drawn entirely from the Instruction Paper without sample copies ?

(20) How many plates are to be sent in at a time ?

ARCHITECTURAL PERSPECTIVE DRAWING

EXAMINATION QUESTIONS

NOTE.—Ordinary foolscap paper ($13\frac{1}{2}'' \times 8\frac{1}{2}''$) is used for the drawing to be made in answer to questions 3 and 8.

(1) State the various particulars that must be considered in selecting the best position of the station point in the perspective of an object.

(2) What effect does the distance between an object and the picture plane have on the size of the image of the object, as shown on the picture plane?

(3) Make a perspective drawing of the square pyramid shown in plan in Fig. I. The base is to be horizontal and 3 inches below the eye level, and the station point S is 4 inches from the picture plane and in the position shown. The height of the pyramid is $3\frac{1}{2}$ inches.

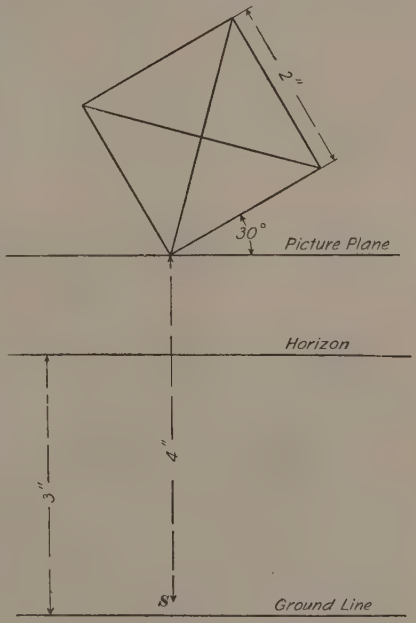


FIG. I

(4) Why do vertical lines have no vanishing points?

(5) Compare an isometric and a perspective drawing, and state the advantages and disadvantages of each, also the points of similarity and contrast. State the purpose for which each is most suitable.

(6) What is meant by the term horizon as used in connection with perspective drawing?

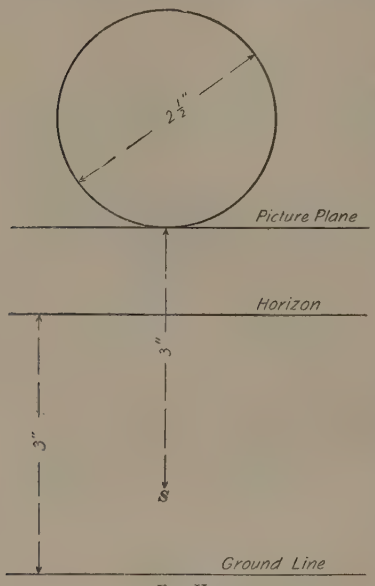


Fig. II

(7) When horizontal lines are parallel and inclined to the picture plane, where is their vanishing point?

(8) Draw the perspective of the circle shown in Fig. II.

(9) What is (*a*) the picture plane, (*b*) the station point, (*c*) the centre of vision?

(10) Draw a perspective of the house shown in Figs. 27, 28, and 30, but with the façade of the house in such a position that it makes an angle of 40°, instead of 30°, with the picture plane. The horizon is at a distance of 6 feet above the ground line, and the distance between the station point S and the picture plane is 60 feet. The arrangement of the various views on the plate is to be similar to that in Fig. 28, and the degree of finish given to the drawing is equal to that of Fig. 30. The ground line is to be $1\frac{1}{2}$ inches above the lower border line and the picture plane $4\frac{1}{2}$ inches below the upper border line. Place the centre of vision $6\frac{1}{2}$ inches from the left-hand border line. The size of this drawing plate is, as usual, $18'' \times 14''$, with border lines drawn $\frac{1}{2}''$ from the edges, leaving a space for the drawing of $17'' \times 13''$.

SHADES AND SHADOWS

EXAMINATION QUESTIONS

NOTE.—Four of the following questions refer to objects of which the shadows have to be found. For this purpose Figs. I to IV have to be redrawn on separate sheets of ordinary foolscap paper ($13\frac{1}{2}$ inches by $8\frac{1}{2}$ inches) to the scale required.

(1) What is meant by a line of shade?

(2) Explain what the line $X\,Y$, found in projection drawings, is intended to represent.

(3) Fig. I shows the elevation and plan of an octagonal plane that is parallel to **VP** and at right angles to **HP**. Construct the octagon by inscribing it in a circle of $4\frac{1}{2}''$ diameter and find its shadow on the **VP** and **HP**.

(4) State which surfaces in architectural drawings correspond to the **HP** and **VP**.

(5) Explain the difference between a shade and a shadow.

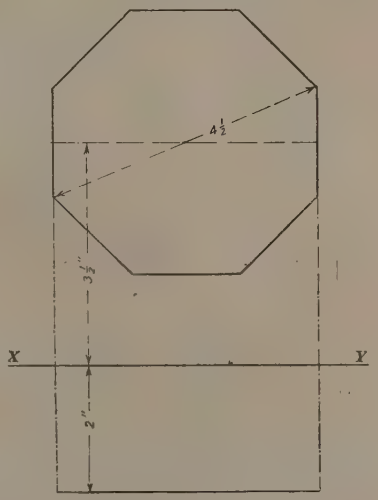


FIG. I

(6) Fig. II shows a short length of a cornice, view (*a*) being a front elevation and (*b*) a section taken along line *x x* in the

elevation. The line *a a* in view (*a*) represents the outside of the wall. It is required to find the shadows of the various members of the cornice. The drawing is to be made to a scale of $1\frac{1}{2}'' = 1$ ft.

(7) If shadows are to be projected in architectural drawings, state in which direction the light is assumed to proceed.

(8) In Fig. III are shown two low coped walls between which is a flight of steps leading up to a terrace. One of these

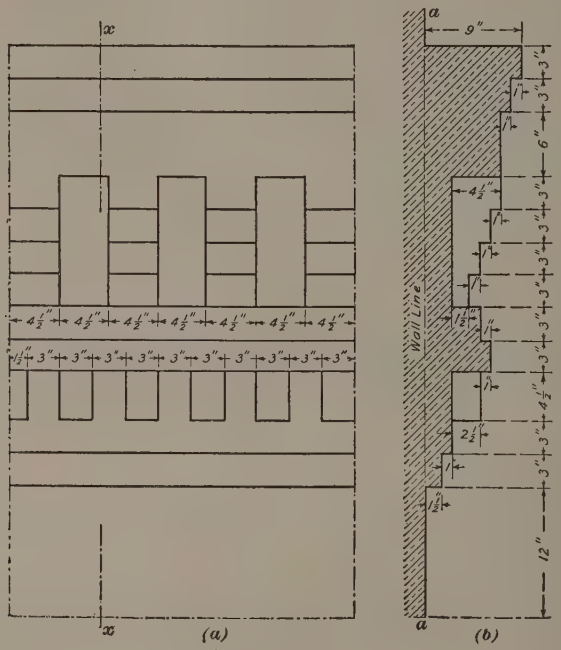


Fig. II

walls abuts against the corner of a house. It is required to show the shadows falling on the steps, terrace, house, and ground. Make the drawing to a scale of $\frac{1}{2}'' = 1$ ft.

(9) If the rays of light, as used in architectural drawings, are projected to the **HP**, state (*a*) the angle of inclination

to $X\,Y$. (*b*) If projected to the **VP**, at what angle do they incline to **HP**?

(10) Fig. IV shows at (*a*) the side elevation of a house, at (*b*) the front part of the plan, which will be sufficient for the purpose of defining the shadows. At (*c*) is shown a section taken along $x\,x$ in view (*a*). The part shown in this section is the

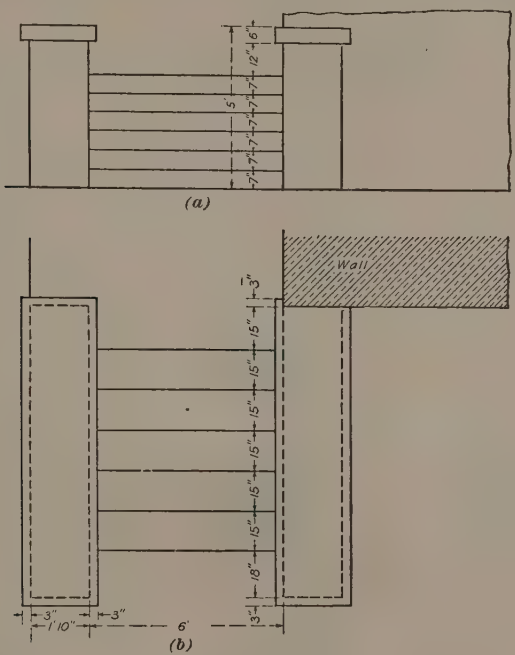


Fig. III

portion situated to the left of line $x\,x$ in view (*a*). Show in the elevation the shadows produced by the various parts, such as the wing, the buttresses, chimney, dormer, etc. The drawing is to be made to a scale of $\frac{1}{4}'' = 1$ ft. It is not necessary to insert the window frames and to show the shadows thrown on them. It will suffice to indicate the windows by blank spaces, as in Fig. IV.

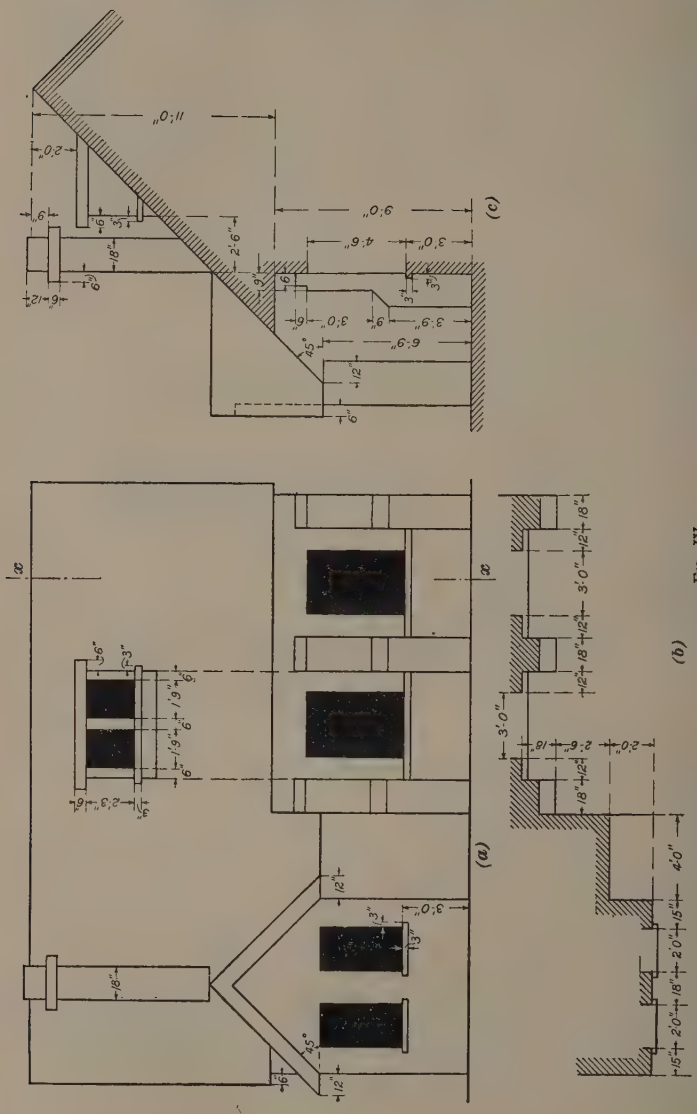


FIG. IV

SKETCHING AND MEASURING

EXAMINATION QUESTIONS

(1) What methods may be adopted for fixing pencil drawings?

(2) How would you measure and plot a rectangular window opening with a segmental head?

(3) What simple method may be used to determine approximate heights, in certain buildings, in the absence of measuring instruments?

(4) What precaution may be adopted, when preparing a preliminary sketch for a measured drawing, to avoid the omission of dimensions?

(5) What particulars should be embodied in a rough sketch and notes of a building, to make the same useful for reference at a later date?

(6) Illustrate the use of the plumb-line in measuring a large moulded cornice.

(7) State a quick and effective method for emphasizing masses of shadow in a sketch.

(8) Illustrate, by means of a sketch, how you would proceed to take the dimensions for the plotting of a segmental pediment.

(9) Give an example in which the use of diagonal dimensions is desirable in the preparation of a measured drawing.

(10) What precaution should be taken to check the general accuracy of a long series of short dimensions?

BLACK-AND-WHITE DRAWING

EXAMINATION QUESTIONS

(1) What is meant by composition in drawing ?

(2) What are the distinguishing characteristics of the drawings of Joseph Pennell ?

(3) Briefly describe how a flat wash should be laid.

(4) Define the term texture.

(5) Describe the characteristics of the pen drawings by D. A. Gregg.

(6) What is meant by rendering ?

(7) What is meant by wash work ?

(8) Analyze the composition of Fig. 36, and describe how the artist has endeavoured to balance his values.

(9) What is meant by the term value ?

(10) What is the great contrast in technique between the work of Maxime Lalanne and that of Herbert Railton ?

(11) Make a scale : (*a*) of five values; (*b*) of three values.

(12) What are some of the common errors of beginners in black-and-white drawing ?

(13) What is the great contrast between the rendering of D. A. Gregg and Maxime Lalanne ?

(14) Define the following terms : (*a*) balance ; (*b*) rhythm ; (*c*) harmony.

(15) How is form expressed in wash drawing ?

(16) What is meant by technique ?

(17) Why are the drawings of Herbert Railton unsuitable for the beginner to imitate ?

(18) Describe the method of mounting a sheet of drawing-paper preparatory to commencing a wash drawing.

(19) What are the distinguishing characteristics of the pen drawings of Herbert Railton ?

(20) What is meant by the term colour in a black-and-white drawing ?

DRAWING FROM LIFE

EXAMINATION QUESTIONS

(1) What change in appearance is given to a figure, when seen from a very low point of view?

(2) Before beginning the blocking in of the figure, what point should be considered as to the size of the drawing?

(3) What aid can be employed in estimating the proportion of the shoulders, breasts, and abdomen?

(4) What is meant by the action of a figure?

(5) In the average figure, what proportion do the legs bear to the trunk, in length?

(6) What other information besides action is conveyed by the first blocking in of the figure?

(7) What guiding points are used in the construction of the torso or trunk of the body?

(8) What part of the body is commonly used as a unit of measurement?

(9) (*a*) If a cross-section of the head were made at the brows, what would be its approximate shape? (*b*) In constructing the head, from a given point of view, what facts should be borne in mind?

(10) What should be the qualities of the lines indicating action and proportion?

(11) Viewed directly in front, what proportion do the eyes approximately bear to the width of the head?

(12) What points on the body are commonly used for the starting and finishing of lines of action and proportion?

(13) Viewed in profile, into what divisions can the face be approximately divided?

(14) In what sequence should the first lines of action and proportion be put in?

(15) By what factor are the estimates of proportion greatly influenced?

(16) What are the proportions of the standard human figure?

(17) What work on the drawing should follow after the lines of action and proportion have been inserted?

(18) What are the main varieties of tone that may be distinguished on a figure subjected to a strong light coming from one direction?

(19) Are the proportions of the figure to be based on actual measurement, or on their appearance from a given point of view?

(20) What is meant by the term modelling as applied to drawing and painting?

ANSWERS

TO THE

QUESTIONS AND EXAMPLES

INCLUDED IN THE

EXAMINATION QUESTIONS

Each Key, or set of Answers, has the same section number as the corresponding set of Examination Questions. All references are to the portion of the text that bears the same section number as the Key in which the references occur, unless the title of some other part of the text is mentioned.

To be of the greatest value, the Key should be consulted sparingly, much in the same manner as a pupil would go to a teacher for assistance in solving a problem he is unable to master unaided. The Key should not be referred to except as a last resource, when the student has failed, after using every reasonable effort, to solve the example or answer the question. If used in this way, the Key will be a help and a source of encouragement in studying the various subjects comprising the Course.

GEOMETRICAL DRAWING

(1) See Art. **2.**
(2) See Arts. **13** and **36.**
(3) See Art. **13.**
(4) See Art. **3.**
(5) See Art. **3.**
(6) See Art. **3.**
(7) See Art. **4.**
(8) See Arts. **7** and **8.**
(9) See Arts. **9** and **10.**
(10) See Art. **12.**
(11) See Art. **11.**
(12) See Arts. **19** and **20.**
(13) See Arts. **14** and **15.**
(14) See Art. **21.**
(15) See Art. **22.**
(16) See Arts. **16** and **17.**
(17) See Arts. **23** to **33.**
(18) See Art. **34.**
(19) See Art. **36.**
(20) See Art. **35.**

ARCHITECTURAL PERSPECTIVE DRAWING

(1) See Arts. **36** to **38.**

(2) See Art. **29.**

(3) A line is drawn in the plan, Fig. **1**, from the vertex b_4 of the pyramid parallel to one of the sides and intersecting the picture plane at a. The vertical $a\ a_1$ through this point is used as a measuring line, on which the height $a_1\ a_2$ of $3\frac{1}{2}''$ is set off. To find the vanishing points, draw lines from S parallel to $b\ b_1$ and $b\ b_2$ intersecting the picture plane at c and d, and project these points to the horizon line, thus obtaining the vanishing points V_1, V_2. Draw radial projectors from b_1, b_2, and b_4, and from their points of intersection with the picture plane draw verticals. Lines drawn from point e to V_1 and V_2 will intersect these verticals at e_1, e_2, and if the latter points are connected by lines to V_1, V_2, these lines will intersect at e_3. A line from a_2 to V_2 will intersect the projector from b_4 at e_4, thus fixing the vertex of the pyramid.

(4) See Art. **39.**

(5) See Arts. **4** and **12.**

(6) See Art. **33.**

(7) See the rule in Art. **35.**

(8) Inscribe the circle in the square $a\ b\ c\ d$, Fig. 2; draw the diagonals $a\ c$, $b\ d$, and through the points of intersection with the circle draw the verticals $a_1\ b_1$ and $c_1\ d_1$. Project points a, a_1, d_1, and d to the ground line, obtaining a_2, a_3, d_3, and d_2. Find the vanishing points of the diagonals by drawing $S\ g_1$ and $S\ g_2$ parallel to the latter. Points V_1 and V_2 are then found in the usual manner. The line $O\ a_2$ gives the direction of the side $a\ b$, and by joining a_3, f, d_3, and d_2 to O, these lines will indicate the positions of the corresponding lines in the plan. The lines $d_2\ V_1$ and $a_2\ V_2$ give the directions of the diagonals, and their points of intersection with the lines from O fix the various points in the square, such

as b_2, c_2, and e_3. A horizontal through e_3 gives points e_4 and e_5. The points obtained will suffice to fix the outline of the circle.

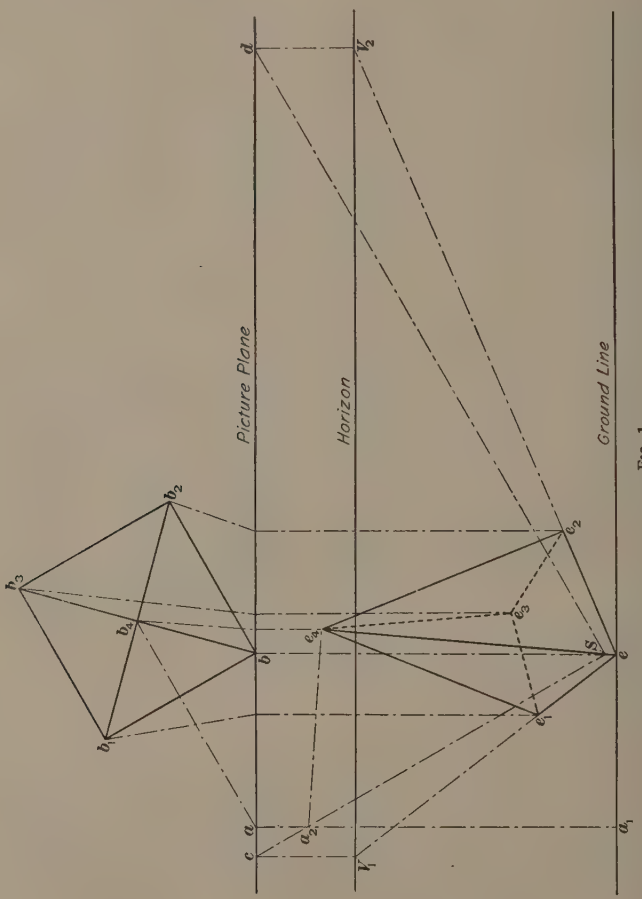


Fig. 1

(9) See Arts. **26** and **27.**

(10) Fig. 3 shows the perspective of the house in Fig. **27,** drawn according to the requirements stated in question 10.

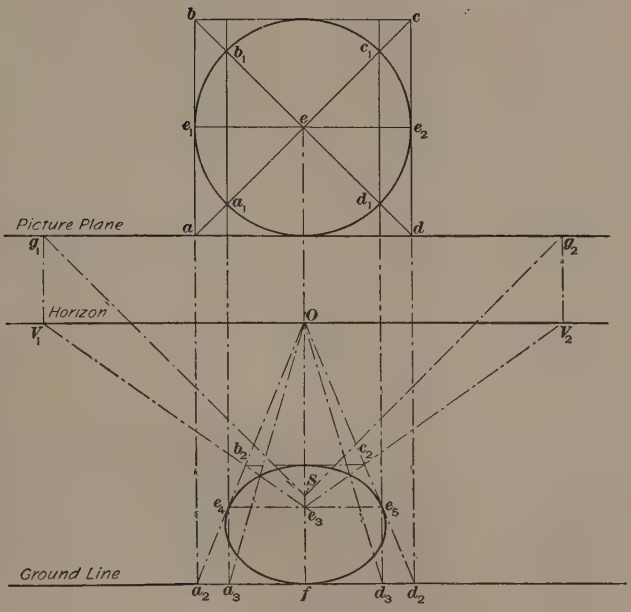
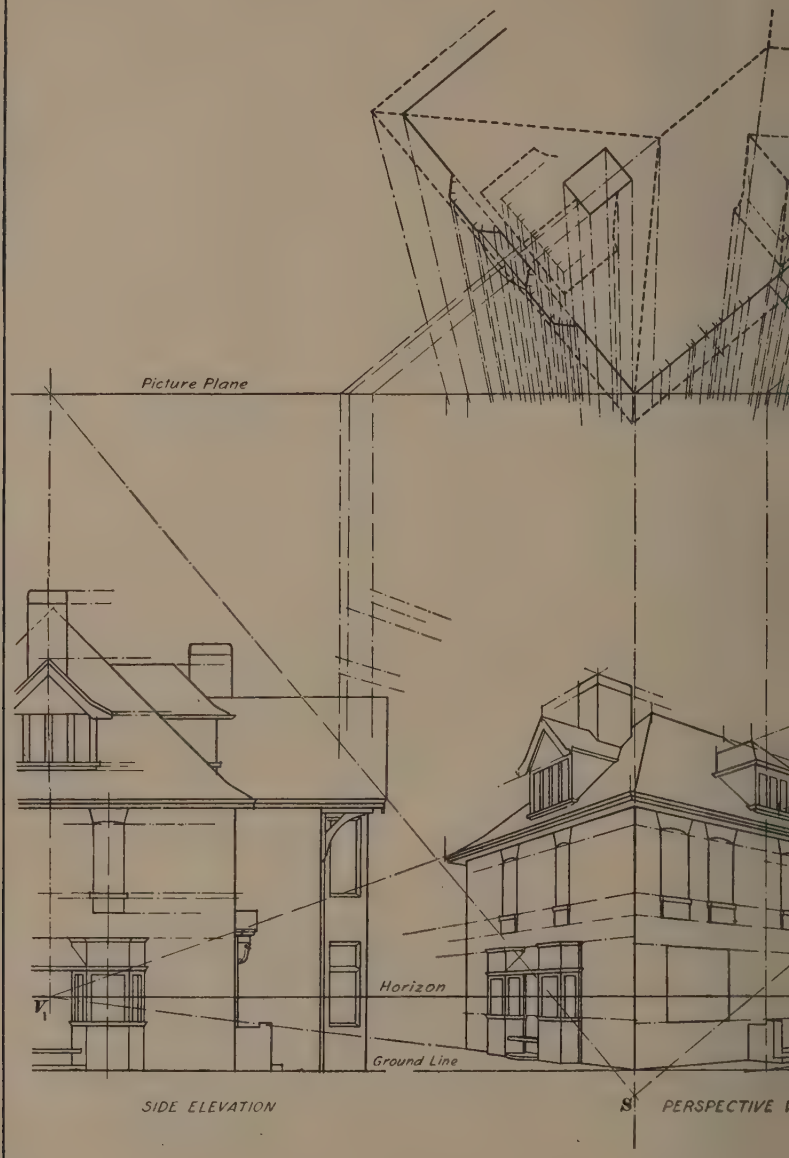
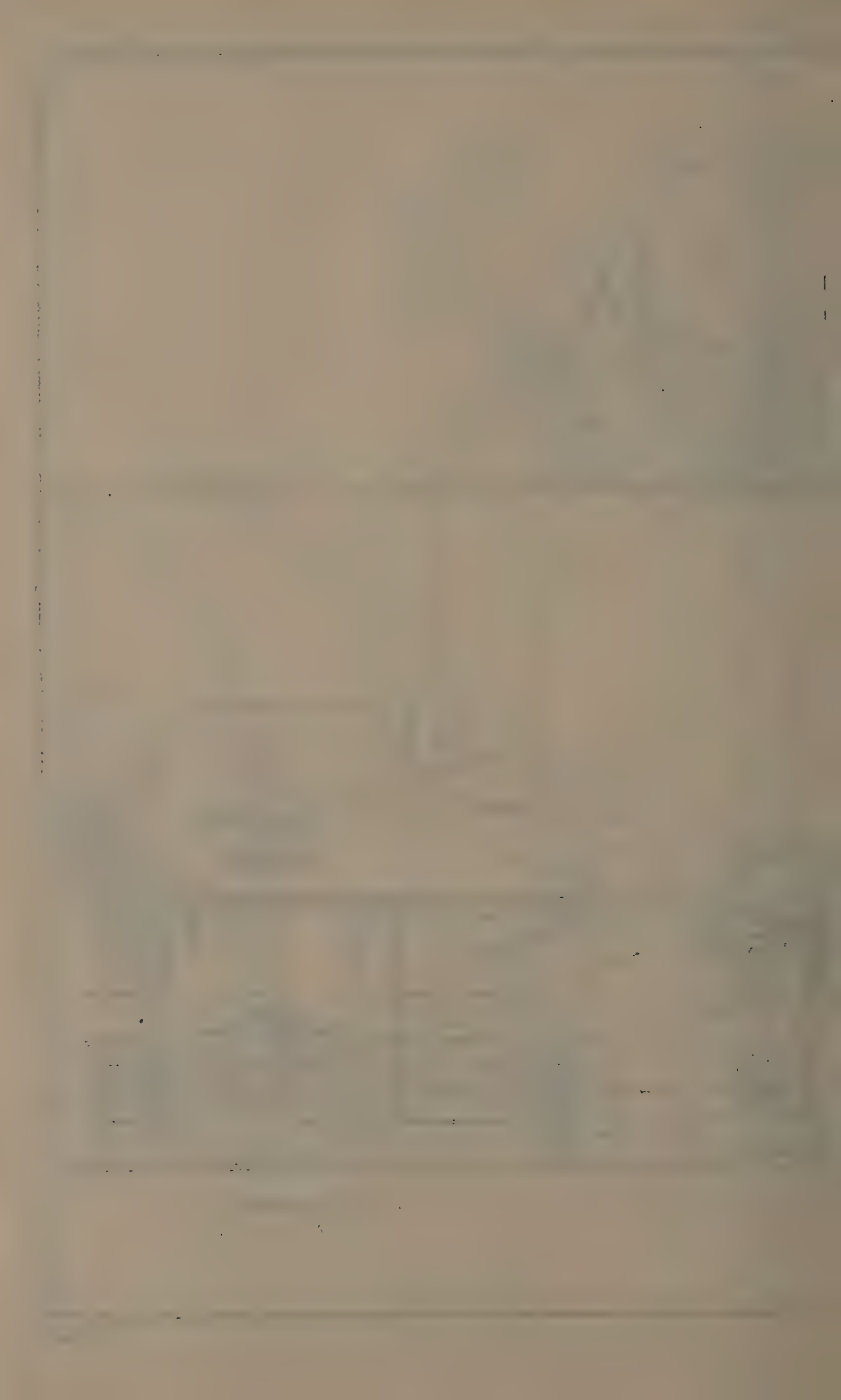

b
c
b1
c1
e1
e
e2
a1
d1
Picture Plane
a
d
g1
g2
Horizon
O
V1
V2
b2
c2
S
e4
e3
e5
Ground Line
a2
a3
f
d3
d2

FIG. 2


Picture Plane
Horizon
V
Ground Line
SIDE ELEVATION
S
PERSPECTIVE

FRONT ELEVATION



SHADES AND SHADOWS

(1) See Art. **11.**
(2) See Art. **17.**
(3) See Fig. **1.**
(4) See Art. **17.**
(5) See Art. **11.**
(6) See Fig. **2.**
(7) See Art. **7.**
(8) See Fig. **3.**
(9) See Art. **8.**
(10) See Fig. **4.**

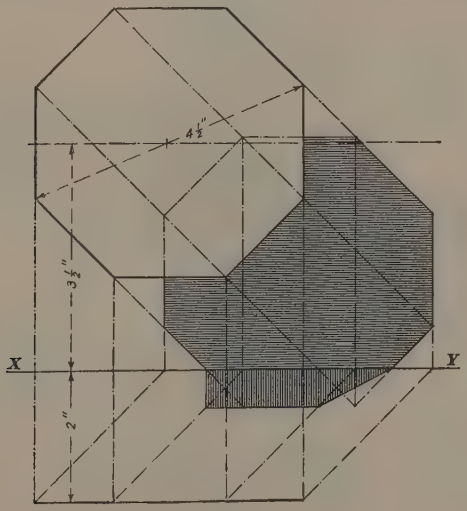


Fig. 1

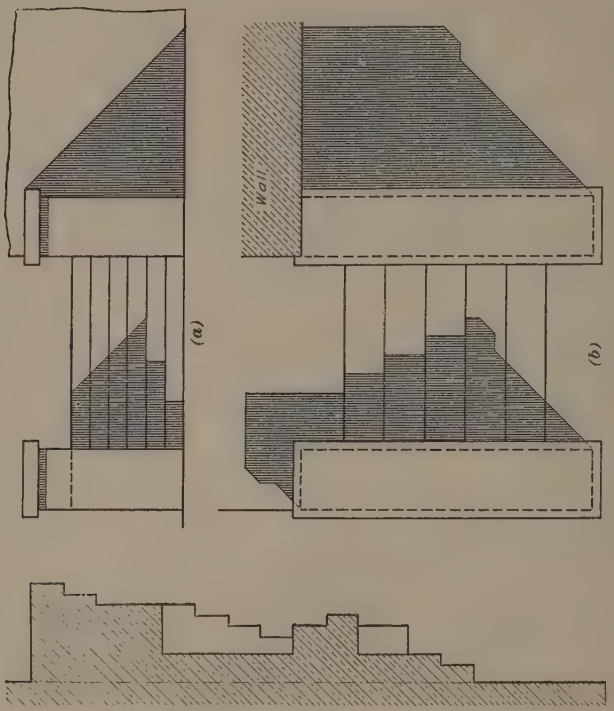


FIG. 3

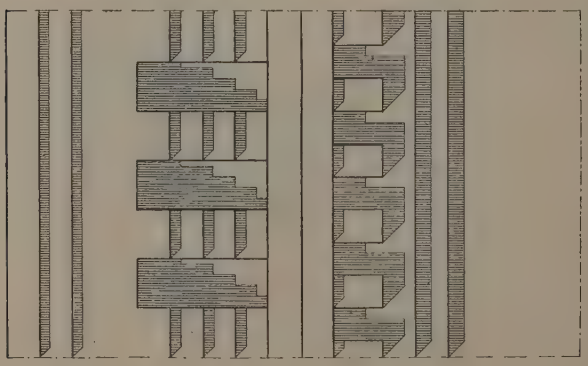


FIG. 2

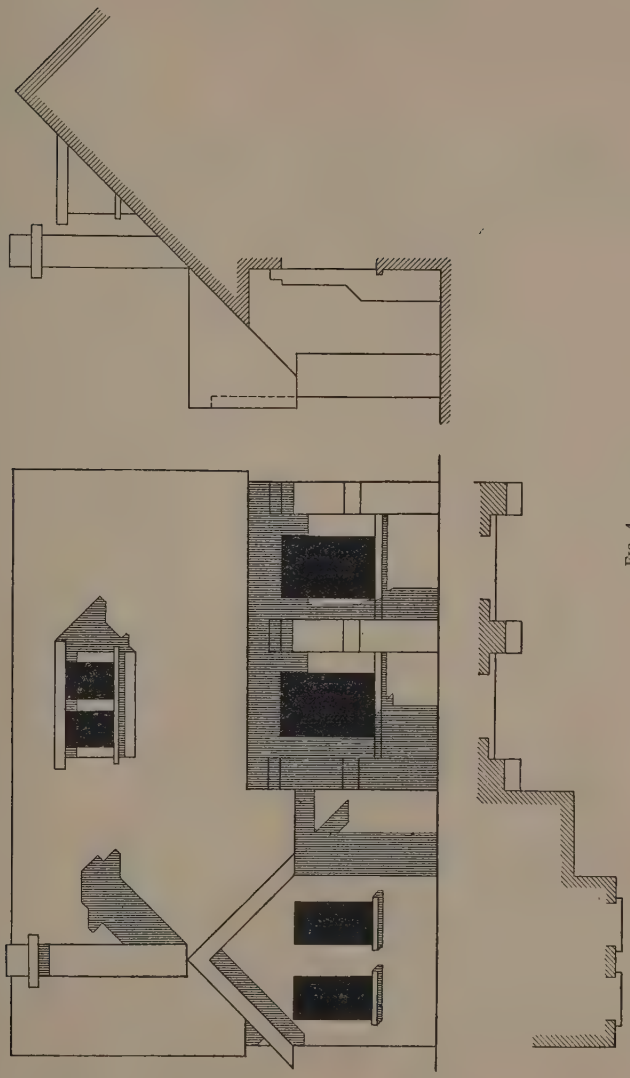


FIG. 4

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(1) See Art. **8.**
(2) See Art. **16.**
(3) See Art. **11.**
(4) See Art. **47.**
(5) See Arts. **9** and **11.**
(6) See Art. **30.**
(7) See Art. **55.**
(8) See Art. **51** and Fig. **35.**
(9) See Arts. **20** to **23.**
(10) See Art. **19.**

BLACK-AND-WHITE DRAWING

(1) See Art. **18.**

(2) See Art. **115.**

(3) See Arts. **130** and **131.**

(4) See Art. **31.**

(5) See Arts. **103** and **104.**

(6) See Art. **1.**

(7) See Art. **122.**

(8) See Art. **103.**

(9) See Art. **8.**

(10) See Art. **114.**

(11) (*a*) See Art. **11** and Fig. **4.**
(*b*) See Art. **27** and Fig. **20.**

(12) See Arts. **35** to **38.**

(13) See Arts. **104** and **113.**

(14) (*a*) See Art. **21.**
(*b*) See Art. **26.**
(*c*) See Art. **29.**

(15) See Art. **124.**

(16) See Art. **14.**

(17) See Art. **114.**

(18) See Art. **128.**

(19) See Art. **114.**

(20) See Art. **8.**

DRAWING FROM LIFE

(1) See Art. **9.**
(2) See Art. **5.**
(3) See Art. **10.**
(4) See Art. **7.**
(5) See Art. **35.**
(6) See Art. **7.**
(7) See Art. **22.**
(8) See Art. **6.**
(9) (*a*) and (*b*) See Art. **18.**
(10) See Art. **8.**
(11) See Art. **18.**
(12) See Art. **8.**
(13) See Art. **17.**
(14) See Art. **8.**
(15) See Art. **11.**
(16) See Art. **6.**
(17) See Art. **8.**
(18) See Art. **16.**
(19) See Art. **9.**
(20) See Art. **14.**

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NOTE.—All items in this Index refer first to the section and then to the page of the section. Thus, *Abacus*, §24, p7, means that *Abacus* will be found on page 7 of section 24. When there are several items having the same key word, this is, for brevity, omitted after the first reference, and the other items are indented, or set in, from the left margin, to indicate this omission, which never consists of more than one word. Thus, under the key word *Arch* is found the indented item, *on corbels, Semicircular ;* this is read *Semicircular arch on corbels*, the capitalization of *Semicircular* denoting the first word of the reference.

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